FOURTH REPORT OF

THE BUREAU OF MINES

1894.

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1. Map of the southeastern part of the Rainy River district, exhibiting the country in the vicinity of Rainy lake and river Seine. Scale, 2 miles = 1 inch.

2. Map of part of the Rainy River district, exhibiting the country in the vicinity of Manitou, Eagle and Wabigoon lakes. Scale, 2 miles = 1 inch.

The maps show all mining locations filed in the Department of Crown Lands to 1st June, 1895.

To His Honor GEORGE AIRY KIRKPATRICK,

Lieutenant-Governor of Ontario:

I have the honor to transmit herewith, for presentation to the Legislative Assembly, the Fourth Report of the Bureau of Mines.

I have the honor to be, Sir,

Your obedient servant,

A. S. HARDY,

Commissioner of Crown Lands.

DEPARTMENT OF CROWN LANDS,

Toronto, April 9, 1895.

FOURTH REPORT OF

THE BUREAU OF MINES.

To the Honorable ARTHUR S. HARDY,
Commissioner of Crown Lands :

SIR,—I have the honor to submit herewith, for presentation to His Honor the Lieutenant-Governor, the Fourth Report of the Bureau of Mines.

State of the mining industry.

The statistics of the sale and lease of mineral lands, as well as those of the production of ores and other minerals, indicate a condition of inactivity in the mining industry of the province which is no doubt a consequence of the depression in business and inertness of speculation so noticeable in other countries, but especially in Great Britain and the United States, where mining enterprise has heretofore been so brisk. Signs of revival however are beginning to appear in those countries, and increased attention is likely to be given to mining operations here as well as elsewhere.

Gold fields of the province.

The gold fields of the province are attracting greater notice, and during the past year the Rainy Lake region especially drew many explorers and capitalists towards it. Numerous discoveries of gold-bearing ore are reported there, four or five locations are being actively developed, and one gold mill is nearly ready for operation. In the Lake of the Woods district the mine and mill on Sultana island have been worked continuously, and it is claimed that free-milling ore is obtained throughout the entire extent of the workings, now about 200 feet underground. Three other promising properties are in course of development with British, American and Canadian capital, and it is proposed to put a mill on each of them this year. At the present time a mill is in course of erection at Harold lake near the upper waters of the Seine river. The Ophir mine and mill in Galbraith township were operated only during a portion of the year, owing, it is said, to an insufficiency of paid up capital ; but the engineer in charge claims that the work done in the mine has proven it to be a good property. The death of one of the principal shareholders, which occurred recently, will doubtless for a time leave the affairs of the company in an unsettled state. The Creighton mine in the township of that name was idle the whole year, but towards the close of it fresh exploratory work was commenced with a diamond drill, and it is reported that a strike of considerable promise has been made ; operations

to more satisfactorily prove the extent and quality of the ore body are now in progress. In the lake Wahnapitae district a location taken up by Mr. Rinaldo McConnell of Mattawa has attracted much attention by the exceedingly rich samples of ore taken from it. A company has been organized to work the property, and a shaft is in course of being sunk upon the vein. In the Marmora district little has been done. Only one property, the Ledyard mine in Belmont, was worked during the year. Some good ore was raised, and a second-hand Huntington mill was set up, which however gave little or no result. A new Huntington mill has been purchased, and will be running in the course of a few weeks. The gold mill built at Marmora to treat arsenical ores by the Walker-Carter process has been closed down for want of ore to treat.

Geologist and Mineralogist of the Bureau.

Early in the year the staff of the Bureau was strengthened by the appointment of Dr. Arthur P. Coleman, of the School of Practical Science, as Geologist and Mineralogist. Dr. Coleman is required to occupy three of the summer months in geological field work and to make a report thereon, besides other duties of an advisory or special character which do not interfere with his professional functions at the school. Last summer was occupied by him in examining the Rainy Lake gold field, and the belt of country northward of it along the Manitou and Wabigoon waters to the line of the Canadian Pacific Railway. His report and the geological maps accompanying it will be found especially valuable to prospectors in that field. The maps have been prepared in the office of the Director of Surveys. The one of the Rainy Lake district is based upon the map of the Geological Survey accompanying Dr. Andrew C. Lawson's report of 1887-8, with additions showing recent surveys of townships and mining locations from the office maps in the Department, and some corrections in the geological coloring by Dr. Coleman. The map of the Manitou and Wabigoon rivers tract is prepared from Departmental surveys.

Nickel and copper mines.

The nickel and copper mines in the Sudbury region have been actively worked during the year, and as the statistics show the production of matte was much larger than in either of the preceding two years. It is gratifying to know that the severe tests to which nickel-steel armor plate has been subjected continue to show its superiority to all other kinds of plate. Development work was carried on at the Point Mamainse copper locations on lake Superior for the greater part of the year, and as a result of the extent and richness of the finds of ore it is expected that substantial mining operations will be undertaken this year.

Northern Ontario.

The growing interest taken in our northern Ontario, both as a field for settlement and mining enterprise, required that all the trustworthy informa-

tion relating to it in many volumes of official reports and elsewhere should be searched out and presented in suitable form. This work has been undertaken by the Secretary of the Bureau, Mr. T. W. Gibson, and the valuable paper on The Hinterland of Ontario is the result of his labors.

Diamond drill exploration.

The diamond drill purchased by the Government last year and placed in charge of the Bureau has been steadily employed since the time that it passed the customs in exploring an iron ore property in the county of Frontenac. Information as to the steps taken to select and purchase the drill and the work done with it is presented in the report. There are sanguine hopes, it may be added, that the iron industry will assume active form in the province this year.

Summer Mining Schools.

At the last session of the Legislature provision was made for Summer Mining Schools at Sudbury and Rat Portage, at which practical instruction might be given for the benefit of miners, prospectors and others employed or interested in mining pursuits. Classes were opened at Sudbury, Copper Cliff and Rat Portage, with an aggregate regular attendance of fifty-one. The report of the instructors in charge shows the scope and character of the work undertaken, and the favor with which the project has been received.

Inspector's report.

The Annual Report of the Inspector of Mines accompanies the Report of the Bureau. It gives details of the progress of operations at each of the mines visited by him, and of their condition as regards the safety and health of miners.

I have the honor to be, Sir,

Your obedient servant,

ARCHIBALD BLUE,

Director.

Office of the

BUREAU OF MINES,

Toronto, April 9, 1895.

SECTION I.

GENERAL INTRODUCTION.

It is never quite safe to say in a Government report that there is a condition of trade stringency in this country, since, theories of trade and commerce having become mixed up with the principles of party politics, a statement of fact upon the subject is apt to be construed as a reflection upon the policy with which the fact is not in accord. But it may be permissible to say that there is business depression outside our own country, the existence and gravity of which the whole world has been obliged to recognize, and that nowhere have its effects been more keenly felt during the last three years than among our neighbors in the United States. This being admitted, and it being known also that the men who have been readiest to invest in mining enterprise here, either in the purchase of mineral lands or in opening and working mines, are foreigners, and chiefly citizens of the United States, the slow rate of progress to be noted in the mineral industry of Ontario will be accounted for sufficiently without the necessity of an assertion on the state of trade in Canada for the men of any political party to differ from or quarrel over. Men who find it troublesome to get money for their own wants at home, either to carry on the operations in which they may be engaged or to provide for the requirements of the household, are not likely to go abroad in search of speculative ventures. When the commercial storm-drum is hoisted the prudent business man, if he does not keep the shelter of the port, does not embark upon unsafe or unknown waters. He waits for the coming of fairer weather ; and that is the conduct of many Americans who have been exploiting Ontario as a promising field of mining enterprise. There is abundant evidence of the shrinkage of business in their own country, two or three illustrations of which may be given. In foreign trade the exports in the calendar year 1894 were less than in 1893 by $50,864,484, and the imports were less by $93,567,306. The production of pig iron, which was 6,657,388 tons in 1894, was less by 467,114 tons than in 1893, and less by 2,499,612 tons than in 1892. Then as measured by transactions in the New York mining stock market, there is proof of well nigh fatal collapse. In 1888 the number of shares sold in that market was 11,689,388 ; in 1889, 4,114,480 ; in 1890, 3,925,926 ; in 1891, 2,522,660 ; in 1892, 1,527,371 ; in 1893, 624,617 ; and in 1894, 350,000. But in this case the decline in business was no doubt due in part to a withdrawal of confidence from the market scheme itself. In London, Eng., the volume of new issues of stocks and bonds last year was larger than in any year since 1892, yet nearly one-half of it is to be credited to the last three months of the year. Of the total amount, £91,835,000, only £5,018,000 was invested in mining and land

The mineral industry in Ontario affected by

trade depression in the United States

and Great Britain.

companies, two-thirds of which went to the new gold and land companies in Western Australia. In the foreign trade of the United Kingdom too there was an increase in the calendar year 1894, the total value of imports and exports being £624,699,957, as against £622,783,043 in 1893. The number of persons employed in and about all the mines during the year was 739,097, being 20,350 more than in 1893, the production of pig iron was 534,904 tons more than in 1893, and the amount of coal raised exceeded by 2,798,399 tons the highest output hitherto recorded, viz., that of 1891. The receipts into the exchequer from April 1, 1894, to March 16, 1895, were £96,835,332, as against £93,700,896 for the corresponding period of the previous fiscal year, and this is also a hopeful sign of the revival. In the United States the condition of the iron trade is a good barometric index of business affairs, and for several months that trade has been steadily improving. In 1892 the production of pig iron in the last six months was 48 per cent. of the whole year's output; in 1893 it was 36 per cent.; and in 1894 it was nearly 60 per cent. The first three months of the current year continue to show a steady improvement, and therefore it may be hoped that better times for American industries and capital are near at hand, the reflex influence of which will soon no doubt be felt in our country, for it is certain that never before were the opportunities for mining enterprise in Ontario so well known to Americans as they are now. But it will be asked why, if the chances are so good and if there is so little business depression felt in Canada, Canadians themselves are not eager to invest? It is easier to ask the question than to answer it. Money in large quantities is known to be lying in the banks. The statement for the month ending 28th February ultimo shows that there was deposited in the banks of Canada by the public payable on demand \$64,555,403, and payable after notice \$115,083,710, making a total of \$179,639,113. The statement for the corresponding date in 1881 showed that there was at that time deposited and payable on demand \$40,474,518, and payable after notice \$38,545,406, being a total of \$79,019,924. This was a period of high water mark in commercial and industrial activity in Canada, and men with money were encouraged to invest in business enterprise rather than deposit in the banks at a low rate of interest or at no rate at all. After fourteen years the deposits are seen to have been increased by over \$100,000,000, one-third of the whole amount being at call and the rest at a rate of interest possibly not half as much as was allowed in 1881. Yet with all that money in Canadian banks at the credit of Canadians, if \$10,000 or \$100,000 is required to develop a promising mineral property—the investment of which would be of course a risk—we must look to the United States or Great Britain for it! The labor of the miner alone may develop the mineral wealth of Ontario, as it has done elsewhere upon rare occasions; but the progress of unaided labor in this department of industry must be slow and precarious. With the help of capital the chance of successful effort may be greatly improved, and it does seem to be a deplorable situation that where nature has been so bountiful the citizen folds his arms and the enterprising foreigner is invited to step in to win and carry away the treasure. When the gas fields of Essex and Welland were opened, pipe lines were laid down to convey

Signs of revival.

Why Canadians do not invest.

Capital lying idle in the banks.

cheap fuel to Detroit and Buffalo. But this, fortunately, is an extreme instance of how mineral fortunes may be given away. To be inspired with confidence in the resources of the country is laudable if the facts warrant it; yet more important is the enterprise which undertakes to develop resources when they are discovered and can be utilized. "The most superficial glance at the present condition of Europe," Alexander von Humboldt wrote fifty years ago, "shows that a diminution, or even a total annihilation of national prosperity, must be the award of those states who shrink with slothful indifference from the great struggle of rival nations in the career of the industrial arts." And again: "Those states which take no active part in the general industrial movement, in the choice and preparation of natural substances, or in the application of mechanics and chemistry, and among whom this activity is not appreciated by all classes of society, will infallibly see their prosperity diminish in proportion as neighboring countries become strengthened and invigorated under the genial influence of arts and sciences."[1] The same idea is elaborated by an able writer of our own day, Benjamin Kidd, in dealing with the results of British methods and enterprise in Egypt and India, which he regards as object lessons that will not be without their effect on the minds of the European races. "It will probably be made clear," Mr. Kidd says, "and that at no distant date, that the last thing our civilization is likely to permanently tolerate is the wasting of the resources of the richest regions of the earth through the lack of the elementary qualities of social efficiency in the races possessing them. The right of those races to remain in possession will be recognized; but it will be no part of the future conditions of such recognition that they shall be allowed to prevent the utilization of the immense natural resources which they have in charge. At no remote date, with the means at the disposal of our civilization, the development of these resources must become one of the most pressing and vital questions engaging the attention of the Western races."[2] This is not a new thing in policy or practice; it is as old as the law that "to him that hath shall be given;" yet the achievements of British administration and enterprise in India and Egypt are illustrations which will not fail of influence elsewhere—not impossibly even in Ontario, if her own citizens neglect or miss their opportunities. In the matter of mineral possessions especially what we require is, first the enterprise to prove by substantial prospecting work that a location has mineral value, and secondly a sufficiency of capital to develop and operate it in a business-like way for profit. These are risks that must be taken before the mineral wealth of our country can be utilized. There is no other way. The real estate miner, who buys and sells mineral lands without expending a dollar in labor to show what they are worth, may have his uses; but he does nothing to convert natural resources into tangible wealth. Unemployed money in the bank or the safe, and ores of gold, nickel, copper or iron in the earth, are in that form alike useless to the service of man. The money must go into circulation, and the ores must be won and their metals made ready for the purposes of commerce and the arts.

Consequences of the lack of enterprise.

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[1]Cosmos, vol. I, p. 51. [2]Social Evolution, p. 347.

Sale and Lease of Mineral Lands.

The number of patents issued for mineral lands last year, with area and purchase price paid to the treasurer of the province, are given by districts in the following table :

Mining lands patented.

Districts.	No. of patents.	Acres.	$
Rainy River	29	1,703	3,928 00
Thunder Bay	4	909	1,817 00
Algoma	5	551	1,740 00
Elsewhere	2	108	161 00
Totals	40	3,271	7,646 00

In 1893 the number of locations sold was 63, having an area of 4,370 acres and realizing $11,498 ; in 1892 there were 65 locations sold, the area of which was 6,200 acres, and the price paid $15,273 ; while in 1891 the sales numbered 289, having a total area of 59,389 acres, for which $117,514 was paid. In the last year however was included a number of sales of locations carried out as to price under the terms of the old Act. Nearly all sales of 1894 were made at the reduced prices of the amending Act, which are fifty cents per acre less than prices under The Mines Act 1892, and the average price was $2.34 per acre against an average of $2.53 for the two preceding years.

The statistics of leased locations are given in the next table:

Mining lands leased.

Districts.	No. of leases.	Acres.	$
Rainy River	48	5,268¾	5,268 75
Algoma	4	298¾	278 75
Nipissing	9	360	285 38
Elsewhere	5	1,123	655 90
Totals	66	7,050½	6,488 78

In 1893 the number of leases issued was 122, embracing 13,046¾ acres, for which the first year's rental was $11,933.90 In 1892 there were leased 95 locations, with an area of 13,122½ acres, upon which was paid for the first year's rent charge $12,314.36. In 1891, 47 locations with an area of 4,998 acres were leased, and the rent charge paid was $4,886. The only item in the transactions of 1894 which exceeded those of previous years was the amount of rentals received on leases granted in previous years, which under favorable circumstances may be counted upon to show a steady increase. The sum received from this source last year was $3,807.78, as against $2,735.86 in 1893 and $603 in 1892, the leasing system having been introduced in 1891.

The following table presents a statement of transactions in mineral lands for the four years 1891-94 :

Comparative statistics.

——	1894.	1893.	1892.	1891.
No. of locations sold	40	63	65	289
Area of locations sold ......acres	3,271	4,370	6,200	59,389
Price of locations sold ....$	7,646.00	11,489.00	15,273.00	117,514.00
No. of locations leased..........	66	122	95	47
Area of locations leased ....acres	7,050½	13,046¾	13,122½	4,998
Rental of locations leased[3] .....$	10,296.56	14,669.76	12,917.36	4,886.00
Total number of locations......	106	185	160	336
Total area of locations ....acres	10,321½	17,416¾	19,322½	64,387
Total revenue from locations...$	17,942.56	26,158.76	28,190.36	122,400.00

The total number of mining locations sold and leased during the four years was 787, with an area of 111,447¾ acres, for which there has been paid into the treasury of the province $194,691.68. The transactions for the first year were abnormal, because many claims under the old Act had been held over for settlement ; while those of last year owe their decrease to the serious depression in business, resulting in the almost total collapse of speculation throughout the continent.

Summary of Mineral Production.

Quantity and value of mineral production in 1894, with number of workmen employed and amount of wages paid for labor.

Product.	Quantity.	Value.	Employés.	Wages.
		$		$
Dimension stone......cubic feet	1,340,000	360,470		
Heads and sills .... "	47,070	15,900	854	336,700
Coursing stone ....square yards	22,000	36,000		
Rubble, etc.........cubic yards	223,000	142,000		
Sand and gravel ... "	733,500	203,450	175	61,650
Natural rock cement ....barrels	55,323	48,774	63	13,020
Portland cement ....: "	30,580	61,060	105	31,858
Lime...... ....bushels	2,150,000	280,000	575	108,000
Drain tile . ...number	25,000,000	280,000	2,375	388,000
Common brick..... .... "	131,500,000	690,000		
Pressed brick, plain..... "	22,460,000	198,510		
Pressed brick, fancy .... "	2,896,000	34,160	209	95,400
Roofing tile .... "	100,000	1,200		
Terra cotta	....	52,360		
Sewer pipe	....	207,000	56	23,000
Pottery	....	134,000	160	47,000
Gypsum..... ...(tons 2,000 lb.)	3,253	9,760	36	9,500
Calcined plaster, etc. "	1,442	22,697		
Salt .... "	35,215	115,551	135	43,350
Nickel .... "	2,570½	612,724		
Copper .... "	2,748	195,750	655	311,719
Cobalt .... "	3¼	1,500		
Gold ....oz....	2,022½	32,776	92	38,032
Petroleum .....imperial gallons	34,912,360	....	....	....
Illuminating oil.. "	14,349,472	1,337,040		
Lubricating oil... "	3,817,181	242,688		
All other oils..... "	10,632,141	343,416	486	279,930
Paraffin wax...........lb....	2,754,300	152,467		
Fuel product	....	71,326		
Natural gas........M cubic feet	1,653,500	204,179	99	53,130
Totals............... 1894	....	6,086,758	6,075	1,840,289
Totals............... 1893	....	6,120,753	7,162	1,935,590

[3] Including rentals from lands leased in previous years.

BUILDING STONE, SAND AND GRAVEL.

The production of building stone has been steadily falling during the last four years, although the number of working quarries has remained nearly the same. The following table gives the number of quarries, value of product and amount of wages paid for labor for each of the years 1891-94:

Production in the four years, 1891-94.

Year.	No.	Value.	Wages.
		$	$
1891	84	1,000,000	520,000
1892	100	880,000	730,000
1893	110[4]	721,000	464,000
1894	96	554,370	336,700

In the larger cities of the province, and doubtless also in the towns and villages, building operations have been very slack during the last three years, which fully accounts for the lessening output. It will be observed that the amount paid for wages in 1892 is much larger than in the other years proportionately to the value of product, and in that year the quantity of dimension stone was also much larger than in the other years; but the difference is more likely to be due to some defect in the returns. When statistics for a number of years have been collected it will be possible to procure averages which can be used to detect and eliminate errors of this sort, the result of oversight or carelessness in filling out the schedules.

Sand and gravel.

Returns of sand and gravel have been obtained for the first time this year. The largest operations are in the Niagara district, near Queenston and on the shore of lake Erie, where building sand of fine quality is obtained, the principal market for which is Buffalo. The total value of output was $203,450, and the industry employed the labor of 175 men.

In the stone quarries the number of employés in 1893 was double the number in 1894, but from the amount of their earnings it is obvious that they worked a much shorter time in the former than in the latter year.

LIME AND CLAY.

Raw material of important industries.

The two most abundant minerals in this country are lime and clay, and they are likewise among the most useful. They furnish the raw material too for mineral industries of the first importance, in which a large amount of capital and many laborers are employed. Yet in the vulgar opinion lime and clay are not worthy of being called minerals, and the seekers after gold, silver, copper, nickel and iron would scorn to recognize the workers in them as fellow-miners. It will not be hard to show however that these very common minerals possess a value not in any degree inferior to the metals, and that they are deserving of much greater attention than they have yet received in this country at the hands of moneyed men and men of the best technical training in the mineral industries.

As to the extent and growth of the industries, information is afforded by the census reports of the Dominion Government. But for comparative records we can only go back to 1881; no account was taken of cements in the censuses preceding the one for that year, and the earlier statistics of the brick industry are of little use in showing its growth.

[4] The report for 1893 (p. 6) gives the number of quarries as 310, instead of 110.

The statistics of the two industries in Canada and the province of Ontario respectively are given in the following table for the census years 1880 and 1890 :

Articles.	Canada.		Ontario.	
	1880.	1890.	1880.	1890.
Lime—				
No. establishments....	1,274	1,184	515	508
Hands employed......	2,537	2,575	1,133	1,005
Wages paid ....$	203,631	465,974	100,200	155,520
Value of product... $	707,132	1,444,453	294,724	478,530
Cement—				
No. establishments ...	9	19	3	12
Hands employed	115	243	29	128
Wages paid ....$	38,151	85,960	7,000	39,245
Value of product....$	91,658	251,175	29,200	153,400
Brick and tile—				
No. establishments....	560	697	400	463
Hands employed.....	4,129	6,737	2,768	3,791
Wages paid . ...$	608,690	1,428,489	405,311	797,257
Value of product....$	1,541,892	3,584,713	971,158	2,154,152

Comparative statistics for 1880 and 1890.

Growth of lime and clay manufacture in Canada, and Ontario's share in it.

The noticeable feature in these statistics is the large share Ontario claims in the progress of the ten years. Ten new cement establishments were added, and all but one are credited to Ontario. The number of hands employed by the industry increased by 128, and all but 29 have been added in Ontario works. The amount paid for wages was greater in 1890 than in 1880 by $47,809, and two-thirds of it was earned in Ontario. The increase in the value of product was $159,517, and three-fourths of it belonged to Ontario. The progress of our province in the manufacture of brick and tile was less conspicuous in the decade, although in number of works, employés, wages and value of output, she exceeds all the other provinces combined. In the increase of works from 1880 to 1890 her share was 63 out of 137 ; of workmen employed it was 1,023 out of 2,608 ; of wages paid for labor it was $391,946 out of $819,799, and of value of articles produced it was $1,182,994 out of $2,042,821. In the lime industry the number of establishments and of hands employed was almost stationary, both in Ontario and the Dominion, but the increase in wages paid for labor and value of product may seem to be surprisingly large. Possibly the lime-kilns had a much longer run in 1890 than in 1880, seeing that in the Dominion the increase in wages paid was 128 per cent. and in Ontario 194 per cent. In value of product the increase in the Dominion was 104 per cent. and in Ontario 207 per cent.

Assuming the absolute accuracy of the figures, there is another aspect of them which arrests attention, viz., the relativity of the cost of labor to the value of product in Ontario and the other provinces. For the whole Dominion in 1880 the ratio of labor to product in the three industries was 1 : 2.74, and in 1890 it was 1 : 2.67—a proportion which everyone would be disposed to accept as likely. For Ontario however the ratios of labor to product were 1 : 2.52 and 1 . 2.81 for the former and latter years respectively, while for the other provinces they were 1 : 3.06 and 1 : 2.53. The use of im-

proved machinery would account for this disparity to some extent, although not wholly. So also would fluctuations in the price or the efficiency of labor. The latter cause can be dismissed as improbable, in view of the proximity of the provinces; and as regards the former it would, in view of all the circumstances, be fatuous to claim for it more than a very modest share of potency in the radical disturbance of ratios. The real cause will probably be found in the different scales of values adopted in different parts of the country, and it is to be regretted that in the census enumerations account was not taken of quantity as well as of value.

The following table gives the quantity and value of the lime and clay products of the province for the four years 1891-4, as collected by the Bureau, together with the amount of wages paid for labor in each industry:

Lime and clay manufactures in Ontario in the four years 1891-4.

Articles.	1891.	1892.	1893.	1894.
Lime—				
Bushels	2,350,000	2,600,000	2,700,000	2,150,000
Value $	300,000	350,000	364,000	280,000
Wages $	116,000	120,000	122,500	108,000
Natural rock cement—				
Barrels	46,178	54,155	74,153	55,323
Value $	18,318	38,580	63,567	48,774
Wages[5] $	....	....	....	13,020
Portland cement—				
Barrels	2,033	20,247	31,924	30,580
Value $	5,082	47,417	63,848	61,060
Wages[5] $	....	....	....	31,858
Common brick and drain tile—				
Number	167,500,000	185,000,000	179,650,000	156,500,000
Value $	1,040,000	1,080,000	1,122,500	970,000
Wages $	432,000	445,000	451,000	388,000
Pressed brick, roofing tile, etc.—				
Number	13,617,909	22,048,000	21,634,000	25,456,000
Value $	156,699	259,335	217,373	286,230
Wages $	58,000	88,865	80,686	95,400
Sewer pipe—				
Value $	270,000	.......[6]	230,000	207,000
Wages $	38,000	....	34,000	23,000
Pottery—				
Value $	45,000	80,000	115,000	134,000
Wages $	....	25,000	36,000	47,000

In the statistics collected by the Bureau, value of product and wages paid for labor are for each year less than those of the census for 1890. The manufacturers of cement in Ontario gave the value of their product in 1894 as $109,834, while the number of workmen they employed was 168, and the amount of wages paid for labor $44,878. Their product included 55,323 barrels of natural rock and 30,580 barrels of Portland cement. In 1890 there was no Portland cement made in our province; yet the value of cement

[5] In the returns for 1891-3 wages for natural rock and Portland cements are not given separately. For both kinds of cement the wages paid for labor were $23,400 in 1891, $53,151 in 1892 and $60,208 in 1893.

[6] No statistics of sewer pipe received for 1892.

manufactured that year according to the census was greater than last year by $43,566, while the number of workmen employed was less by 40, and the wages paid for labor less by $5,633. Had we the output for the census year in quantity, the cause of the discrepancy would more clearly appear. The Bureau's returns of brick and tile for 1894 are also much lower in value than those of the census for 1890, but this is no doubt due to the fact that the financial stringency of last year caused many works to close down early in the season, while others were idle the whole year. The following table shows the value of lime and clay products for each of the last four years according to the Bureau's returns, with the amount of wages paid for labor, and also the value of all mineral products of the province and the wages paid for labor in the same years :

Articles.	1891.	1892.	1893.	1894.
Lime and cements—				
Value ....$	320,441	435,997	491,415	389,834
Wages ....$	139,400	173,151	182,708	152,878
Clay products—				
Value ....$	1,511,699	1,419,335	1,684,873	1,597,230
Wages ....$	528,000	558,865	601,686	553,400
Totals, lime, cements and clay—				
Value ....$	1,832,140	1,855,332	2,176,288	1,987,064
Wages ....$	667,400	732,016	784,394	706,278
Mineral products of the province—				
Value ....$	4,705,673	5,374,139	6,120,753	6,086,758
Wages ....$	1,659,141[7]	2,591,344	1,935,590	1,840 289

It has been shown that on the basis of values the manufacture of cement in Canada increased from $91,658 in 1880 to $251,175 in 1890. The whole of this product was consumed in the country, but it was far from supplying our needs. In the fiscal year 1880-1 we imported hydraulic Roman and Portland cements to the value of $53,765, and in 1890-1 to the value of $323,690. But since the fiscal year 1886-7 the Trade Tables give us the quantity as well as the value of cements imported, and they show that the demand has been largely on the increase. The following table gives our imports of Portland and Roman cements for each of the seven fiscal years 1886-93, the great bulk of which was the Portland variety : Imports of cement.

Year.	Barrels.	Value.
1886-7	102,750	$148,054
1887-8	122,402	177,158
1888-9	122,273	179,406
1889-90	192,322	313,572
1890-1	183,728	304,648
1891-2	187,233	281,553
1892-3	229,492	316,179
1893-4	234,231	284,964

[7] Not including wages paid in the petroleum, pottery and salt industries this year.

The total importation in the eight years was 1,374,431 barrels, valued in the Trade Tables at $2,005,534 ; but to this should be added the $546,435 of customs dues paid to the Government, the costs of freight and insurance and the profits of importers, in reckoning the price paid by the consumers—an aggregate of not less than $3,750,000. In these eight years the increase in quantity was 128 per cent., and in value 92 per cent. But a more striking evidence of the growing demand is afforded by a comparison of the imports of Portland and Roman cements for 1880-81 and 1892-93. In the former year their value was only $45,646, and in the latter it was $284,964, being an increase of nearly 525 per cent. in 12 years. This is a rate that perhaps has not been equalled in any other article of Canadian importation. What is the secret of it, and is the demand likely to be maintained?

Prospect of an increased consumption of cement.

The answer to these questions may be summed up in a significent term of very modern usage on this continent, viz., good roads. The setting in of the era of good roads in this country, as well as in the United States, does not date back ten years, but in that short period much has been learned on the subject, and the street engineer is now as much of a specialist and quite as useful in his way as the military engineer or the mining engineer. The Roman roads of Europe, which have lasted out the traffic of two thousand years, have taught him the invaluable lesson that the only sure way to make a good road is to lay a good and strong foundation. But instead of using stone material, as the Romans did in constructing their great military roads, he has adopted the concrete used by them in the construction of temples and other public buildings, some of whose walls have been standing 2,400 years. The great dome built by Agrippa, the friend of Augustus, "the immortal monument of the Pantheon," as Gibbon described it—now the church of Santa Maria della Rotonda—is an edifice in concrete, and though ravaged by fire and assaulted by the Huns and Goths, it is still intact after more than 1,900 years. Concrete is the street engineer's material for street building, and his chief reliance in the making of it is not Roman or any other kind of natural cement, but the stronger and more durable Portland. In Toronto during the last five years not less than 150,000 barrels of cement have been used in making concrete for street construction, and of this quantity Mr. Rust tells me that not more than 4,000 barrels have been the native hydraulic cement. "Up to the last year or two," he says, "it was all imported Portland cement from Europe." In other towns and cities of the Dominion cement is also being used in steadily increasing quantities in building sewers and streets, and the results are so uniformly good that the material promises to grow steadily in favor. It is almost certain then that for many years yet to come the demand for Portland cement will continue as experience proves the utility and permanency of the concrete roadbed.

But why should we remain dependent on foreign sources of supply for Portland cement? We have in Ontario abundance of raw material for producing it. In scores of localities beds of white shell marl of large extent and excellent quality are found, some of them at the bottom of lakes in which myriads of fresh water shells yet survive, to add to the thickness of the deposit as one generation follows another, and others of them on the sites of

lakes long ago filled up with peaty mould or drained by continental elevations. This marl, if unmixed with sand, clay, peat, or other matter of mineral or vegetable origin, is almost pure carbonate of lime, and furnishes the principal material for the manufacture of Portland cement. The necessary proportion of clay is a matter of experiment, but in all cases the purer and more uniform the quality of the marl, the easier it is to get a right mixture.

Quality of Portland cement produced in Ontario.

Our manufacturers in Ontario have acquired their experience slowly and dearly. Mr. Rathbun told me that it cost him five years of testing, with the aid of a chemist, before he was convinced that it would be safe to start his works. Mr. Butchart also told me that it cost his company several thousands of dollars, a visit to some of the best Portland cement works in England—where he was admitted as a special favor—and the service of two experts in the construction of a suitable plant, before they could produce a commercial article. But the Rathbun Company and the Owen Sound Company have succeeded, and during the last three years they have been producing a Portland cement which satisfies every requirement.

Mr. C. H. Rust, deputy city engineer of Toronto, makes this statement concerning it, in a letter which I have received from him :

"Since 1892 we have used a quantity of Portland cement made by the Rathbun Company at Napanee mills, and by the Owen Sound Company at Shallow Lake. Both these brands are quite equal to the majority of the imported cements, and no doubt when their facilities for manufacturing are increased nearly all the cement used in this city will be of home manufacture."

The Owen Sound Company had the misfortune last summer to lose its mill by fire, but a new one has been erected in its stead. The company has a large supply of raw material alongside of the works, suitable clay for mixing being found immediately below the marl, and doubtless the capacity of the new mill has been designed to meet the growing requirements of the trade.

The only other Portland cement works in the province are at Marlbank in the county of Hastings. The site was chosen because of its nearness to a very large deposit of marl ; but although English capital was put into the business, and presumably English experience also, the enterprise had to pass through the usual ordeal of disappointment and delay before a successful beginning was made.

The output of those three mills last year was 30,580 barrels, but one of them was burnt down early in the season, and another worked only part time. Had their capacity been eight times as great they could barely have supplied the quantity of Portland cement imported by Canada during the fiscal year 1893-4, and obviously therefore there is ample room for the home manufacture to grow. With raw material so abundant and accessible, and with capital seeking new channels of investment, and labor seeking employment, why should we not produce in the country all the Portland cement that our market requires ? An article of uniform quality will always be in request by customers, and with care on the part of the manufacturer there is no reason why he should not be successful in supplying a distinct brand. But as long as we are de-

pendent on foreign makers we cannot hope to be supplied with cement of uniform quality, for when large orders have to be filled it is the common practice of even large mill owners to buy lots from other manufacturers and so make a prompt shipment. The result is that there are as many brands as makers, and with cements of different qualities, some quick-setting and some slow-setting, it is hardly possible to make a first-rate concrete. This is a risk which may easily be avoided if orders are placed at home, with the home manufacturer, and the good results obtained from our Ontario cements are no doubt due to the fact that orders are honestly made up, each manufacturer being jealous of his own reputation.

Growth of clay products.

As regards the products of clay, it is not necessary that much should be said. Taking the various articles of common and pressed bricks, terra cotta, tile, sewer pipe and pottery, the number of men employed in their manufacture in Ontario last year was 2,800, with earnings of $553,400. The aggregate value of their products was $1,597,230, or more than one-fourth of all the mineral production of the province in the same year. This fact alone suffices to prove the importance of our clay industries; yet it is obvious that they are capable of greater development. The manufacture of pressed brick and terra cotta began here only six years ago, and last year, in spite of the collapse in the building trade, the value of the output of six works was $286,230. It gave employment to 209 workmen and paid them wages to the amount of $95,400. The improvement already noticeable in the architecture of our cities as a consequence of the use of pressed brick and terra cotta is bringing this material fast into favor, and it may be said that the earth affords no better building material than a properly burnt brick, and none which so readily lends itself to the production of handsome architectural effects. In the strong and fine-textured shales of our Hudson River and Medina formations, conveniently situated and easily quarried, Ontario is favored above most provinces and states in America.

Pressed brick and terra cotta.

The same shales are also found to be suitable for the manufacture of sewer pipe, with proper mixtures, and last year the output of two establishments employed in this industry was $207,000, employing 56 workmen, and paying wages to the amount of $23,000.

Vitrified brick.

Another clay industry is now on the eve of commencement, and if successfully established it promises to be a great boon to our towns and cities, viz., the manufacture of vitrified brick for street paving. In Ohio, Illinois, Iowa and other American states this has now grown to be a very important industry, and it is supplying a material for street construction which on all points of merit is not equalled by any other hitherto employed for the purpose. Many mistakes were committed by the first makers of paving brick, and there is much yet to be learned as to the clays or clay mixtures which give the best results, as well as to the proper degree and duration of heat to produce a hard, tough and impervious brick. But much is already known, and with careful experiments and close observation many works are enabled to produce with regularity a high percentage of paving brick of uniform quality from every charge of a kiln. A number of experiments have recently been made in Toronto, Hamilton and elsewhere in this province, and

although each expert will assure you that he alone knows the secret, and that no one else has the clays for a right mixture but himself, you may rest assured that in a matter of this sort the key and the ward are not so hard to match as the tribe of experts would have you believe. In several instances encouraging progress has been made, especially with the Medina and Hudson River shales.

We may therefore, I think, look with confidence to an early beginning of the production of paving brick in Ontario; and when that time comes we shall be no longer at the mercy of trust concerns like the owners of Pitch Lake asphalt, as illustrated last summer in the case of a contract for paving in the city of Hamilton. When we are producing Portland cement from our own shell marls and clays to the full extent in which it is required for street concrete, and paving brick from our own shales to cover the concrete, we shall be as independent as we ought to be in supplying ourselves with the materials of such everyday requirements as are called for in the building of good roads. In so doing also we shall be utilizing our raw materials of clay and lime, otherwise of no value, finding profitable investment for capital lying idle in the banks, and giving employment to hundreds if not thousands of men who for lack of work to do are finding it hard to win their daily bread.

Importance of accurate experiments.

Reference has been made to the experiments conducted by the manufacturers of brick and cement, preliminary to the building of works to commence production on a commercial scale. These experiments demand patience, exactness and scientific method, as well as the use of costly appliances. Why should they not be taken up in our technical schools, where there are professors having the necessary expert knowledge and training, and the appliances for making tests and ascertaining results with unerring accuracy? The importance of the clay industry has been so well recognized by the Legislature of Ohio that a course of practical and scientific instruction in the art of clay-making and ceramics has been added to the educational work of the state University, and the first term of this department opened in September of last year. Work of that character is as much needed in Ontario as in Ohio, and the professors of our scientific schools cannot too soon prepare to enter upon it.

GYPSUM AND SALT.

Gypsum areas in the Grand River valley.

Gypsum and salt, though entirely different in their chemical composition, are characteristic minerals of the Onondaga formation, which extends over a large area of western Ontario.

In the lower basin of the Grand river, from Paris to Cayuga, beds of gypsum occur in isolated areas. Several have been worked for more than fifty years, and although the gypsum industry has never been an important one, it has managed to exist, and at the present time the yearly value of products is perhaps greater than ever before. This is wholly due however to the new uses found for it in the manufacture of alabastine and a material for destroying the voracious potato bug. Increased quantities are also used in the pro-

duction of calcined plaster. As a fertilizer ground plaster will not bear long transportation, and the market for it is limited to the district in which it is produced.

The salt area of western Ontario.

The salt area was at first supposed to be confined to portions of the counties of Huron and Bruce, but borings made during recent years have shown that it extends into parts of Middlesex, Lambton, Essex and Kent. It appears likely indeed that the thickest beds are in the last named county, but they are at a much greater depth than elsewhere. A well bored two years ago at Windsor, county of Essex, struck a very good deposit, and a large quantity of salt was produced last year at the works erected there. In Huron and Bruce for some cause the industry was less active than in former years, and the total product of the province was less than in any year since 1891. In the latter year the product was 44,167 tons, valued at $157,000 ; in 1892 it was 43,387 tons, valued at $162,000 ; in 1893 it was 48,450 tons, valued at $149,850 ; while last year it was only 35,215 tons, valued at $115,551. It may be remarked also that with the decrease in the business there is a corresponding difficulty in procuring returns from the manufacturers.

NICKEL, COPPER AND COBALT.

Operations at Sudbury.

In the Sudbury district last year operations were carried on by five mining companies upon seven locations, and the quantity of ore smelted was larger than in any former year. The statistics for 1890 and 1891 are not available for a full comparison, as they embraced only the quantity and value of ore raised and smelted, and the amount of wages paid for labor. For the three succeeding years the statistics are as follows :

Comparative statistics in 1892-4.

—	1892.	1893.	1894.
Ore raised ....tons	72,349	64,043	112,037
Ore smelted . ... "	61,924	63,944	87,916
Ordinary matte............. "	6,278	7,176	10,410
Bessemerized matte......... "	1,880	452	1,470
Nickel contents..... ...... "	2,082	1,653	2,570½
Copper contents .... "	1,936	1,431	2,748
Cobalt contents .... "	8½	19	3¼
Value of nickel ....$	590,902	454,702	612,724
Value of copper............. "	232,135	115,200	195,750
Value of cobalt ...."	3,713	9,400	1,500
Men employed .... no.	690	495	655
Wages paid ....$	339,821	252,516	311,719

In the Report of the Bureau for 1893 the nickel contents of the matte were given as 1,642 tons instead of 1,653. The error occurred in the returns of one of the companies, and a correction subsequently made was overlooked in compiling the statistics. It may be stated here that the estimates of metallic contents of the matte are computed from the averages of analyses made at the works and entered on the forms returned to the Bureau, as are also the values of metal contents.

The next table gives the quantity of ore raised and smelted for each

of the five years 1890-94, and the average per cent. of metallic contents of ore smelted in the three years 1892-4 :

Percentage of metallic contents in ore.

Year.	Ore raised, tons.	Ore smelted, tons.	Per cent. of metallic contents in ore smelted. [8]		
			Nickel.	Copper.	Cobalt.
1890	130,278	59,329	....	....	.....
1891	85,790	71,480	....	....	.....
1892	72,349	61,924	3.36	3.19	.1007
1893	64,043	63,944	2.21	2.38	.0800
1894	112,037	87,916	2.92	3.14	.0721

The total quantity of ore raised in the five years is 464,497 tons, and the total quantity smelted 344,593 tons, from which it appears that there is in stock or in the roast heaps 119,904 tons. For the three years 1892-4 the computed metallic contents of matte product is 6,305½ tons nickel, 6,115 tons copper and 30¾ tons cobalt. At the average rate of these three years the nickel contents of ore smelted in the five years would be 10,165 tons, and the copper contents 9,857 tons. The output of the mines last year was more than in any previous year excepting the first; but the output of the furnaces shows a large increase, being 16,436 tons in excess of 1891, the year in which the United States government made its purchase of 4,536 tons of matte to supply nickel for use in the manufacture of nickel steel for armor plate. The most likely cause of the increase of production is the fall in the price of nickel, which is due largely to improved processes in separating it from the matte.

Valuation of metallic contents of matte.

The total value of nickel, copper and cobalt in the matte, based upon the selling price at the works, was $826,750 in 1892, $579,302 in 1893 and $809,974 in 1894. All the matte produced in the Sudbury district is shipped to the United States or Europe, where it is treated and the several metals extracted from it in the forms required for commercial use. This is the costliest and most difficult part of the process, and of course no account is taken of it in computing the value of the metallic contents here. To compute values on the basis of the market price of refined nickel, copper and cobalt in Europe or the United States would be very misleading. The following table gives the average values per ton and per pound computed at the selling price per unit of metal contents at Sudbury for each of the three years 1892-4 :

Year.	Nickel.		Copper.		Cobalt.	
	per ton.	per lb.	per ton.	per lb.	per ton.	per lb.
	$	cents.	$	cents.	$	cents.
1892	283 81	14.190	119 90	5.995	436 82	21.841
1893	275 08	13.754	80 50	4.025	494 73	24.736
1894	238 36	11.918	71 23	3.561	461 54	23.077

[8]The ores of only one company contain cobalt, and in 1892 the ores of one company yielded no copper; all the ores carry nickel. Percentages are calculated on the ores containing the several metals, and not on the aggregate quantity of ores.

Comparison of values and market prices.

The statistics of the Bureau are for the year commencing 1st November and ending 31st October. The London, Eng., quotations for this period show that in the year 1892 the price of refined nickel ranged from 2s. sterling in February to 1s. 10d. in July and 1s. 9d. in October, the average being 1s. 11d. In 1893 the average was 1s. 8d., ranging from 1s. 9d. in the first half of the year to 1s. 7½d. in the latter half. In 1894 prices ranged from 1s. 7½d. from October to May and then fell steadily to 1s. 7d. in June, to 1s. 6d. in August, to 1s. 5d. in September, and to 1s. 4d. in October, the average being 1s. 6d. Reduced to our currency, these averages would be 46½ cents per pound in 1892, 40½ cents in 1893 and 36½ cents in 1894; but from 1st November, 1891, to 31st October, 1894, the market price fell from 48½ to 32⅓ cents per pound, or 33⅓ per cent. Prices in the United States have ruled higher nearly by the amount of the customs duties, or from about 56 cents per pound in 1892 to 48 cents in 1893, and to 41 cents in 1894. It will be observed that in comparing average values at Sudbury with average prices in London and New York, there is a discrepancy for 1893, and there is a strong probability that the fault is in the returns made to the Bureau for that year. The average of London prices for copper (good merchantable brand cash) in 1892 was £44 9s. 6d. per ton, in 1893 £43 14s., and in 1894 £40 14s. 5d.; or, in our currency, 9.65 cents per pound in 1892, 9.44 cents in 1893, and 8.83 cents in 1894. Here again there is an obvious disagreement between market price and value, although not of the same character, being one of proportions.

The number and classification of workers employed at the mines during the four years 1891-4 are given in the following table, together with the total amount of their wage-earnings each year:

Comparative statistics of workmen and wages, 1891-4.

Year.	Workers of 15 to 17 years		Workers of over 17 years		Total workers.	Total wages.
	above ground.	under ground.	above ground.	under ground.		$
1891..	25	....	439	244	708	322,201
1892..	10	....	483	197	690	339,821
1893..	10	....	356	129	495	252,516
1894..	17	....	395	243	655	311,719

The Mines Act 1892 provides that no boy under the age of fifteen years shall be employed in any mine below ground, and that no boy of fifteen and under seventeen years of age shall be employed in any mine below ground for more than forty-eight hours in any one week, or more than eight hours in any one day. It also provides that no girl or woman shall be employed at mining work, or allowed to be for the purpose of employment at mining work in or about any mine. It will be seen by the foregoing table that only a few boys between the ages of fifteen and seventeen years are employed above ground, and that none are employed below. It will be noticed also that a much larger number of men were employed above ground in 1891 and 1892 than since, no doubt because of the fact that more work of a preliminary nature

was required at the opening of the mines. The amount of wages includes as well what was paid to workers at the roast heaps and at the smelting furnaces as to those employed directly at the mines above and below ground; consequently the actual cost of mining the ore cannot be computed. Neither can the labor cost of the quantity of ore smelted or of its matte product, since the whole of the ore raised in any year was not treated in the furnace. In 1893 however the quantity smelted was only 99 tons less than the ore taken from the mines, and for that year the average labor cost of ore when reduced to matte would be $3.95 per ton. For the three years 1892-4 the total wage-earnings at the mines and works was $904,056, and the total value of matte product $2,216,026. Salaries of managers and clerks are not included in wages, and no data are available to show the cost of mining supplies and fuel or the labor saving value of mining machinery and smelting plant.

Processes for cheapening nickel.

Reference has been made to new processes of refining the metallic contents of matte, and especially to the cheapening of nickel as a result of these improvements. An invention of Robert M. Thompson of the Orford Copper Company had a noticeable effect on prices three years ago, and metallurgists since then have not been idle in the search for better methods.

It is a well-known chemical fact that copper in the presence of and in connection with any member of the iron group of metals is not attacked by an acid or acid solution, and that in solution of any copper salt a complete separation of that metal may be obtained by the addition to the solution of metallic iron or any other element of the iron group, such for instance as nickel or cobalt. Upon this principle Messrs. Grant and Richardson, of Toronto, have devised a method for the refining of the copper-nickel mattes of the Sudbury district and obtaining, it is claimed, in a cheap, simple and effectual manner, a complete separation of the two metals, each absolutely free from any trace of the other. This process is especially applicable to the blown or Bessemer mattes, which usually contain but a small percentage of iron, and is described by the inventors as follows:

The Grant-Richardson invention for refining nickel-copper mattes.

"In the first place the matte (which may contain nickel, copper, iron and cobalt) is crushed to a moderate degree of fineness and then roasted to complete oxidation in a reverberatory or other suitable furnace. The resulting mixed oxides are then placed in a suitable receptacle, provided with means whereby the contents may be properly stirred or agitated and there subjected to the action of heat and a suitable reducing gas, such as hydrogen, carbon monoxide, natural gas or water gas, until complete reduction of the metallic oxides has taken place. It is important that this reduction be made, because it helps the process in the subsequent treatment with sulphuric acid as hereafter described. The sulphuric acid will fail to act upon a coarse mixture of the metals so as to obtain a separation of them, but if the oxides are reduced to a finely divided mixture of the metals the action is immediate and very rapid, whereas in the former case the action is exceedingly slow and stops after a certain period, owing to the accumulation of undissolved copper on the surface of the lumps. If much iron is present in the matte it is considered preferable to increase the temperature towards the close of the operation of reduction in order that the resulting metals may not be too strongly pyro-

phoric. At this stage of the process the matte has been reduced to a finely divided mixture of nickel and copper and a small quantity of iron, if any were present in the matte under treatment. This finely divided mixture is then removed to a suitable tank and there subjected to the action of an acid, preferably diluted sulphuric. By the action of this acid the iron and nickel pass into solution as sulphates, while in the presence of the nickel scarcely any of the copper is attacked. In this operation by keeping the reduced metals in excess with respect to the acid a solution may be obtained absolutely free from copper, but in practice it is preferred to use such a quantity of acid as will fully combine with the whole of the iron and nickel present. In this case the resulting copper slimes are left absolutely free from nickel and iron, while it is found that a small proportion of copper sulphate is present in the resulting solution. To precipitate this, the solution is placed in another tank and there acted upon by a fresh portion of the finely divided metals in order to neutralize any free acid and completely precipitate all traces of copper therein. The solution is then carefully filtered or decanted from the slimes in the tank and subjected to the action of chlorine gas or atmospheric air by passing streams of the same through the solution in order to peroxidize the iron and cobalt if the latter be present. The iron or iron and cobalt may then be precipitated by any of the usual and well known methods. The remaining solution of nickel sulphate may then be used for the preparation of any of the nickel salts, or the nickel may be precipitated as nickel hydroxide by the use of lime and then converted into the oxide or metal. It is preferred however to allow the hot solution to cool and the larger proportion of the nickel sulphate to crystallize out and to use the mother liquor to dilute fresh portions of the acid. The nickel sulphate so obtained is then roasted to oxide in a reverberatory furnace, and the oxide reduced if so desired by any of the usual methods to metallic nickel. It is claimed by this method that a nickel chemically free from any trace of copper may be obtained, a fact of immense importance in the production of ferro-nickel for the manufacture of nickel steel."[9]

[9] Experiments continue to be made also to simplify and cheapen the process of converting the ore into matte. Mr. James McArthur, general manager of the Canadian Copper Company at Copper Cliff, has been at work for some time in improving a method of his own invention, and the following account of a trial run of fifteen pots of matte he has given me since this report was presented to the Legislature: "The pyritic or green ore smelting trial on Monday the 8th inst. (April), was a nine hours' trial run, of a larger scale test than that of last year, and was simply to determine the present value and future modifications of certain parts of this process, as we have as yet no permanent instalment for its operation. This can only be arrived at by occasional trials from time to time, as opportunity offers, without interfering with the general run of work. But the principle of the process as embodied in my application for patent rights has so far proved its value by trial. It will however take a more lengthy trial to form anything like a correct idea as to costs, wear and tear, repairs, etc. To me the matter of importance is, to provide from the molten bath in the crucible or bessemerizing section of the furnace the requisite hot air for the partial oxidation and smelting of the green ore fed in at the upper section of the furnace. This I arrive at by a constant bessemerizing action on the crucible bath from which the hot and spent air ascends to the green ore in the upper section of the furnace, performing a second duty on the ore charge, making the operation continuous in one furnace and without the use of external hot-blast ovens. But as the ores of this district are not heavy in sulphur, they cannot furnish all the heat required for their own treatment, and the difference is made up with carbonaceous fuels. The furnace is vertical, composed of lower and upper sections. The upper has volume tuyeres and is contracted in width for two feet below this point, while the lower has the regular bessemerizing tuyere. I will not speculate on the extreme probabilities of this as a future process, but await the opportunity for further results by trial."

The process has been patented in Europe and America, and if refined nickel can be produced by it at the low cost estimated by the inventors it will no doubt soon be brought into practical use.

GOLD AND SILVER.

Silver mines closed down.

No work was carried on in the silver mines of the province last year. The low price of silver which closed down so many large mines in the United States two years ago has continued its effect there. Silver indeed fell steadily in price last year, and until the market for it revives none but the richest and best producing mines are likely to be worked. The owners of silver properties in Ontario are therefore not sanguine. Gold mining offers better attractions, but it has not yet reached a business basis in Ontario. A number of properties upon which work was carried on in 1893 remained idle last year for lack of capital or enterprise. Of the four which have made returns only three were metal producing mines, and one of these gave results of only a few days' milling. Another was worked only part of the year owing to financial difficulties; and there is but one that can rank as a mining enterprise. The following table gives the statistics of gold mining for the three years 1892-4, as fully as they have been furnished:

Progress of gold mining.

—	1892.	1893.	1894.
Mines worked ....no.	9	15	4
Men employed above ground.... "	85	112	40
Men employed under ground ... "	40	56	52
Ore mined ....tons.	3,710	5,560	2,428[10]
Gold product ....oz.	....	1,695	2,022½
Gold value ....$	36,900[11]	32,960	32,776
Wages paid ...."	22,750	49,027	38,032

These are not very satisfying figures, but they will no doubt be greatly improved upon in 1895. There is every promise of work being carried on more vigorously, by better methods and at a larger number of works.[12]

PETROLEUM AND NATURAL GAS.

Common origin of petroleum and natural gas.

Petroleum and natural gas are now generally believed to have had a common origin. The latter originates under many conditions in which the

[10] The returns of ore mined in 1894 are complete only for two of the three producing mines. [11] This value is estimated, as only a small part of the ore was milled.

[12] During the present winter promising development work has been carried on upon locations in the Pine Portage district, a few miles southeast of Rat Portage, under the direction of Mr. Torrance, M.E., of Montreal, and arrangements are being made to put a mill there. The Rainy Lake region was visited last month (March 11-16) by Mr. William Margach, Crown Timber agent at Rat Portage, and he reports prospecting work on a number of locations. "I was at the Wiegand, Hillier, Sterling & Bull and Barclay & Mosher camps on the north shore of Seine river and on Shoal, Wild Potato and Bad Vermilion lakes. At the Wiegand mine there is one shaft down 20 feet and another 25 to 30 feet, from both of which they are taking out rich ore. They are getting out timber and preparing to build a mill. At Hillier's mine a five-stamp mill is completed and they are waiting for warm weather to start it; there is a large ore pile at this mine. At Sterling & Bull's two shafts have been started, one down 20 and the other 10 feet, with a dozen men at work. J. G. McIntyre of Niagara Falls, N.Y., pulp manufacturer, has bought one location from Mosher & Kelly for $40,000, and one from Mosher, Barclay & Haight for $65,000, paying $5,000 down. I met him there with his expert, and they were qulte sanguine. The woods were full of explorers, where the snow has gone on the highlands; and at a little boarding house at the mouth of the Seine river, 18 by 24 feet, thirty of us found accommodation."

former does not appear, Professor Orton says, but petroleum is never found free from inflammable gas, and in a large way all the facts and occurrences of both so exactly correspond that it is impossible to separate them in respect to their origin. Small quantities of oil have been found in the gas fields of Welland and Essex, and an opinion prevails that in Essex there are great storehouses of oil which prospectors are taking means to discover. In Petrolia and Oil Springs every oil well gives off more or less gas, and in the early days of the industry in Lambton the gas flow was very considerable; but in those days no thought was taken of utilizing gas as an article of fuel.

Revival of the petroleum industry.

The petroleum industry has experienced a recent revival by an increase of price which set in during the latter part of last year, but the effect is not noticeable in the returns made to the Bureau. For the current year there will no doubt be improvement, at least in the value of products; for it may be doubted if the fields now worked can be made to yield a larger supply of crude than they have been producing in recent years. It is certain however that promising districts will be tested, and probably one or two abandoned fields will receive attention again. Already enquiries are beginning to be made concerning the supply of petroleum in the region of lake Athabasca, in the Northwest territories, where some test borings have been made under direction of the Geological Survey; and if prices are maintained the enterprise of oil men may be depended on to explore and operate every field within practicable reach. The fuel value of petroleum and its products is now so well established by means of new processes that for this use alone the demand is likely to keep up.

Comparative statistics of production and value of crude.

The following table gives the quantity of crude petroleum produced in the Petrolia and Oil Springs fields for each of the four years 1891-94, and the value of it computed from the average prices for crude:

Year.	Imperial gals.	Value.	Val. per gal.
		$	cents.
1891	31,312,645	1,209,558	3.863
1892	28,000,000	1,000,000	3 571
1893	34,055,000	1,099,868	3.230
1894	34,912,360	1,094,852	3.136

Recent market quotations for crude.

There was a steady decline in average price from 1891 to 1894, and in the latter year quotations fell from $1.01 per imperial barrel in January to 92 cents in May, rising to 93 cents in June and July to 95 in August, and 98 in September, until $1.11¼ was reached in October. Since then the advance has been steady to the present time, averaging $1.12 per barrel in November and $1.15½ in December, $1.16½ in January, $1.20 in February and $1.27 in March, reaching $1.31 at the end of the last month.

Statistics of the refining industry.

The refining industry, which at one time was carried on extensively in London, is now for the most part located at Petrolia. Reports of the quantity and value of the several products of all the refineries have not been obtained for any year, but sufficient statistics have been supplied from which

to obtain reliable averages for the three years 1892-94. From these data the following estimates have been computed :

Product.	1892		1893		1894	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Illuminating oil, gal.	10,862,894	$919,315	13,322,320	$1,372,209	14,349,472	$1,337,040
Lubricating oil "	3,457,570	138,304	4,239,847	277,500	3,817,181	242,688
All other oils "	7,654,723	272,577	11,220,705	323,156	10,632,141	343,416
Paraffin wax, lb.	647,950	70,239	2,250,000	143,325	2,754,300	152,467
Fuel product	....	....	....	72,500	....	71,326

The total value of distilled product in 1892 was $1,400,435, in 1893 $2,188,690 and in 1894 $2,146,937. The returns of 1892 did not give the number of workmen employed at the refineries ; but in 1893 there were 515, with wage earnings of $302,000, and in 1894 there were 486, with wage earnings of $279,930. The industry gives employment directly and indirectly to many other workmen, at the wells and in the manufacture of plant, machinery, outfits of various kinds, etc., but there are no ready means of obtaining statistics of these.

Evidence of the progress made in the refining of crude oil is shown by the following table, which gives the percentages of the several products except paraffin and fuel material obtained at the refineries in each of the three years : Percentages of product from the crude.

Product.	1892 p.c. of crude.	1893 p.c. of crude.	1894 p.c. of crude.
Illuminating oil	38.67	39.12	41.10
Lubricating oil	12.35	12.45	10.91
All other oils.....	27.34	28.14	30.45
Totals......................	78.36	79.71	82.46

The gain in all oils extracted from the crude in 1894 as compared with 1892 is shown to have been 4.10 per cent., and in illuminating oil alone 2.43 per cent. Much progress has also been made during recent years in the quality of illuminating oil, which is now little inferior to the best American, although the crude contains a much higher percentage of sulphur.[13]

[13] The difficulty of extracting sulphur from Canadian petroleum by a cheap and expeditious process has long beset our refiners, and many experiments have been made to overcome it. The latest of these, known as the McKam process, gives promise however of producing refined oil from the Canadian crude equal in illuminating properties, color and freedom from odor to the best American brands. From the applications which have been made to the Canadian and United States patent offices for letters patent, it appears that there is placed in the still one or more tubes, each having an open end above the level of the charge, and extending in a series of V shapes from one end of the still to the other, with an exit into the condenser. These tubes are filled with coarse or lumpy lime and litharge in dry form, and when the vaporized oil rises to the top of the still and escapes through the tubes into the condenser the sulphur contained in it is taken up and retained by the lime and litharge, for both of which it has a strong affinity. It is claimed that in this way the desulphurization and refining are completed by one process, and that 40 per cent. of pure illuminating oil may be extracted from the crude at less cost than by any system hitherto adopted. If the process will accomplish all that is claimed for it, much will have been done to raise the standard of our illuminating oil and to encourage the oil pumping and refining industries of the province. To facilitate the filling and cleaning out of the tubes, it should be explained, openings are made at the upper and lower angles, with caps to be put on or taken off as may be required ; and any common refining still may be fitted up with the improved apparatus.

Natural gas.

The chief feature of interest to note in connection with natural gas in 1894 is the laying down of a pipe line in the county of Essex to connect the gas field on the shore of lake Erie in that county with the city of Detroit. The total length of this line is about 35 miles, but as it was not completed until December the output does not enter into the statistics of the year. The chief value of the natural gas product of Ontario now is reaped by Detroit and Buffalo, whose citizens enjoy whatever boon this cheap and clean fuel affords. Formerly those cities had drawn supplies of gas from the Ohio and Pennsylvania fields, but these in time became so far depleted that the supplies were cut off. A few years more or less will witness the exhaustion of the Ontario fields also, yet without Ontario profiting to any extent worthy of mention from the utilization of this gift of nature. The following comparative table for the three years 1892-94 shows the extent to which the gas fields of the province have been developed :

Tapping Ontario fields into the United States.

Comparative statistics for three years 1892-94.

—	1892.	1893.	1894.
Producing wells, ...no	73	107	110
Gas product ....M cu. ft	....	2,342,000	1,653,500
Value of gas. ....$	160,000	238,200	204,179
Miles gas pipe..................	150	117	183½
Workmen, ...no	....	59	99
Wages for labor..............$	55,000	24,592	53,130

The gas product of the wells for 1892 was not given, and although the number of producing wells was slightly increased last year it appears that the yield was much less than in 1893, the decrease being 688,500,000 cubic feet. The pressure of the Welland wells has fallen very much owing to the large quantity delivered to Buffalo consumers, and last year it became necessary to erect a pumping station to maintain the flow. Obviously there is an error in the returns of miles of pipe line in 1892 or 1893, and the strong probability is that it is in those of the former year. The cost of labor, it may be observed, is chiefly for boring of wells and laying down of pipes.

Prospects for Iron-making in Ontario.

A long interval of non-production in Ontario.

The last attempt to produce pig iron in Ontario appears to have been made in 1854, and since then the iron manufacturers of our province have been dependent upon outside sources for supplies of the material. Many attempts have been made during the forty intervening years to establish blast furnaces, but hitherto none have been successful. At the present time however a renewal of this important industry is in a fair way to be realized, and both Hamilton and Kingston have shown an interest in giving encouragement to capitalists with that end in view.

A blast furnace in course of erection at Hamilton.

In Hamilton substantial progress has already been made, and the outlook is now favorable for the blowing in of a coke iron furnace before the close of the present year. The promoter of this undertaking is Mr. J. J. Moorehouse of New York state, who has had large experience in iron-making in his own

country, but more especially with charcoal iron furnaces in Connecticut. Having obtained satisfactory assurances of aid from Hamilton if works were located there, Mr. Moorehouse proceeded to organize a company of American and Canadian capitalists with an authorized stock of $1,000,000, and a charter for the Hamilton Iron and Steel Co. was taken out under the provisions of the Ontario Joint Stock Companies' Act.

Officers of the company.

The officers of the company at the first were: William Foster, jr., of New York, president; John H. Tilden of Hamilton, vice-president; William V. Reynolds of New York, secretary; and J. J. Moorehouse now of Hamilton, treasurer and general manager. These with Robert Jaffray of Toronto, John Milne, James Moorehouse and John G. Langdon of Hamilton, and A. M. Card of New York city composed the board of directors; but it is understood that Mr. Tilden will soon succeed Mr. Foster as president, and that an effort will be made to interest a larger proportion of Canadian capital in the concern.

The city's evidence of good will.

Hamilton has shown its good will to the company by granting a site of 75 acres, situated on Burlington bay, adjoining the city limits, in the township of Barton, at a cost of $35,000; together with a bonus of $40,000 in city debentures payable when the furnace is completed, and a further bonus of $60,000 for steel works if erected within a specified time. In addition to the site of 75 acres, the company is authorized to fill in and occupy the water front out to a line of eight feet of water. As dumping ground for furnace slag this is a great convenience, and when the work is finished the area of the location will be not less than 150 acres.

Contract for the furnace and buildings.

A contract for erection of necessary buildings, stack, ovens, boilers and engines, and all works above the foundations was let to the Philadelphia Engineering Works (Ltd.) on 28th October, 1893. In detail the contract calls for the following:

Blast furnace 16 ft. in bosh and 75 ft. high from floor of hearth.
Three fire-brick hot blast stoves, 19 ft. diameter and 60 ft. high.
Wrought iron hoisting tower.
One pair cross compound condensing blowing engines; steam cylinders 42 by 72 in. and 60 in. stroke; blowing cylinders 84 in. and 60 in. stroke.
Eight boilers 59 in. diameter, 24 ft. long with five 12 in. flues.
Draft stack for boilers 75 in. diameter clear and 125 ft. high, of steel plate lined with fire brick.
Cast house 50 by 160 ft.; engine house 47 by 65 ft.; boiler house 50 by 80 ft., and stock house 70 by 230 ft.

The contract provides that the furnace shall possess all modern improvements and be capable of smelting 200 tons of pig iron per day when using 60 per cent. ore and Connellsville coke; that it shall be constructed in all respects to obtain the very best economy in consumption of fuel and handling of materials, both in production of iron and manufacture of steel; and that it shall be furnished with blowing engines of the most economical type. It also provides that the blast shall be heated by three fire-brick hot blast stoves, of the Gordon-Cowper-Whitwell patents, with casing and valves suitable for a working pressure of 20 lb. per square inch, and all furnace construction and piping made suitable for this pressure.

Progress of the work.

The company began work on the foundations in November, 1893, and these were completed for the furnace contractors to commence the erection of buildings and plant in October, 1894, all the iron work and machinery for which are manufactured ready to be put together at their Philadelphia shops. The brick walls of the cast house, and the casings of the furnace stack and the hot blast stoves were erected during the winter; but the casing of the furnace was overturned during a heavy gale in March, and it was decided to discontinue further operations until the completion of the spur making connection with the Grand Trunk Railway, when all heavy machinery can be cheaply and expeditiously delivered on the ground.

Delays in executing the contract.

Under the original agreement the furnace should have been completed by 31st December last, but owing to unavoidable delays the time was extended to 1st July. A further extension has since been made to 1st October, as a consequence of the storm accident, and the officers of the company are sanguine that everything will be in readiness to blow in the furnace by that date. The total cost of the works, exclusive of the steel plant, will be over $400,000.

The following interesting reference to this enterprise is taken from the New York Iron Age, the chief authority on the subject of iron manufacture in America:

The New York Iron Age on the project.

"The situation of the furnace is an excellent one in many respects. It is just outside of the north east limits of the city of Hamilton, and close to the harbor, while the track of the Grand Trunk Railway is but half a mile away, connection with which has already been made.[14] Hence, when the furnace docks are completed, ore and fuel can be dumped close to the stack from ships or from cars, and the pig iron can be shipped to the chief consuming points by an all water or an all rail route. About 60 acres of the 170 acre tract given by the city is solid ground with no obstacles to furnace operations; the remainder is swampy and can be filled in as needed.

Advantages of the Hamilton furnace.

"The Hamilton furnace will have several advantages over all prospective competitors, which comprise the coke furnaces of Nova Scotia and of the United States, the competition of American iron having practically driven out Scotch iron from Ontario. In Hamilton itself there is a large quantity of pig iron consumed, and the town lies within about 100 miles of most of the other places in Ontario which afford an important market for this commodity. Hence, in freight on the pig iron shipped there will be an average of about $5 per long ton advantage for the Hamilton plant over its Nova Scotia competitors. It will also have an advantage in freight charges over its nearest American rivals, although a small one. But against American competition it will have the more substantial advantage of the duty and bounty of $4 and $2 per short ton, respectively, or, together, $6.72 per long ton. This sum in itself is almost equal to the whole cost of making pig iron in some sections of the United States at the present time. There is still another advantage

[14] This statement is not quite accurate. The track has been graded nearly all the way, but completion of it was stayed by the refusal of the owner of a lot to sell the right of way over it at a price that was considered reasonable. This difficulty has been settled however, and it is hoped that connection with the Grand Trunk will soon be made. I was informed by officers of the company that the engines and all other necessary parts of the plant are boxed and ready for shipment from Philadelphia as soon as the spur line is built.

which a blast furance in Ontario is offered, or at least will have an opportunity in sharing, over other pig iron establishments, not only in foreign lands, but in all other provinces in Canada. This is the bounty offered by the Ontario Parliament at its last session. This bounty is payable to the miners or producers of iron ore in the province, but as the conditions require that, in order to secure the bounty, the ore shall also be smelted in the province, it will be seen that the furnaceman's position will enable him to obtain much if not all of the benefit, especially if there be competition in the production of the ore. The sum of money appropriated for these iron bounties is $125,000, and is available for a period of five years from July 1st, 1894. The miners or producers are to be paid the equivalent of $1 per short ton of the pig metal produced from their ores, but not more than $25,000 is to be paid in any one year. If more ore is mined and smelted than the $25,000 at $1 per ton of pig would be sufficient to meet, the payments are to be on a pro rata basis per ton. Consequently if 25,000 short tons of pig iron be made in one year from Ontario ores, the makers will possibly enjoy in the reduced price of ore the equivalent of a bounty of $1 per short ton of pig iron ; if 50,000 tons of iron be similarly produced in one year, the bounty would be equivalent to 50 cents per ton of smelted iron.

"From the foregoing, it will be seen that it is possible for the Hamilton furnace to enjoy for several years the equivalent of a protection of $7.84 per long ton on its product against British and foreign competition, and of $1.12 per long ton against Nova Scotian iron, besides the additional great advantage over the latter in freight for central Ontario markets. Great as these advantages seem to be in these days of keen competition, they are offset more or less by the conditions attaching to the supply of ore and fuel. With regard to the latter article, all its important competitors are more favorably situated than the Hamilton furnace. It will have to depend on Pennsylvania coke, which at the lowest prices can scarcely be delivered at Hamilton below $4 per ton. (Coke is in the free list of the new tariff.) But the important matter of ore supply has yet to be settled. That there are extensive deposits of rich iron ores in Ontario has long been known. Many of the deposits have been worked, and when prices were high thousands of tons of ore were shipped to the United States, the users bearing testimony to its excellent quality. But nearly all the discoveries and the mining have been of magnetite. To obtain a sufficient supply of hematite to mix with the magnetite in order to produce good foundry iron will probably be the first difficulty to be overcome by the completed Hamilton furnace. As iron ore is also on the Canadian free list, it may even be found profitable at the extremely low prices prevailing for lake Superior ores for the Hamilton company to use the product of the Michigan and Minnesota mines in whole or in part, at least until more extensive ore developments are made in Ontario. But these questions will have to be answered with regard to the conditions prevailing some months hence. It is scarcely necessary to add that when the Hamilton furnace is completed and started the results of its operation will be watched with keen interest by Canadian iron men and metallurgists, and by some

Supplies of ore and fuel.

American furnacemen near the border, who marketed 24,951 short tons of pig iron in Ontario in the fiscal year 1894."

The Kingston project.

The projected blast furnace and steel works at Kingston have not yet got beyond the stage of negotiation with the promoters, but hopes are entertained that they will go on if the city will grant aid along certain lines, the principal ones being a temporary loan to the promoters and a free site.

Ontario Iron Mining Fund to encourage the production of ore in the province.

In the session of 1894 the Legislature of Ontario made provision for the purpose of encouraging miners to open up and work the iron deposits of the province, conditioned upon the ore being also smelted in the province. For this object a sum of $125,000 has been set apart as an Iron Mining Fund, out of which the Treasurer may pay "to the miners or producers of ore upon all iron ores which shall be raised or mined and smelted in the province for a period of five years from the first day of July, 1894, the equivalent of one dollar per ton of the pig metal product of such ores." It is provided however that should a larger quantity of ore be raised or mined and smelted in any one year than the sum of $25,000 will be sufficient to meet the payments for at the rate here mentioned, then payments to the miners or producers of ore shall be made upon a pro rata basis, so that no more than $25,000 shall be paid for the produce of ores in any one year. It is also provided that payments out of the fund shall cease at the end of five years from the first day of July, 1894, and that any balance of the fund remaining after payment of earnings to that date shall be returned to the treasury of the province. The aid thus provided, together with the bonus of $2 per ton granted by the Dominion Government and the customs duty of $4 per ton, is equivalent to an advantage of $7.00 per short ton (or $7.84 per long ton) over all foreign competitors, a sum that is more than half the cost of the selling price of pig iron in the United States and Great Britain. For the supply of local markets in Hamilton, Toronto, London, Brantford, etc., there is the further advantage over foreign makers of iron which the cheaper freight affords.

Testing an iron ore deposit with the Government diamond drill.

The diamond drill purchased by the Government of Ontario to explore mineral properties has been steadily employed in testing the iron ore deposit of the Glendower mine since November, and it seems likely that as a result of its operations the mine will be re-opened this year.

Peat Fuel and Peat Litter.

Efforts to produce peat fuel.

The utilization of the large deposits of peat found in Ontario has been discussed in former reports of the Bureau, and is undoubtedly a matter of prime importance to the people of the province. It was hoped that the efforts of inventors and experimenters would result in producing a good article of peat fuel which could compete in both quality and price with coal, and while giving employment to native capital and labor would do something towards defeating the natural monopoly which the coal-miners of Pennsylvania and Ohio possess of the Ontario market. This hope is as yet unfulfilled, though in one or two quarters the claim is made that the vexed problem of manufacturing an economic peat fuel has been solved. It is seldom that a new and useful process springs complete from an inventor's brain into the

commercial world, and only the tests of time and trial, which are as yet unapplied, can show whether these claims are well or ill founded.

The utilization of peat for moss-litter.

Meantime an undoubted advance has been made in the utilization of the peat bogs of the province by the discovery that the upper surface of at least some of them is well suited for the manufacture of moss-litter, which is so extensively prepared and used in the countries of continental Europe, and is rapidly coming into favor in England and America. Its value as a bedding for horses and cattle is greater than that of any other article employed for the same purpose, and is due largely to the extraordinary capacity which it possesses for absorbing liquids and ammonia. In this respect its superiority over straw is very marked, and the cleanliness resulting from its use has a very beneficial effect upon the health of animals.[15]

Operations on the Welland bog.

The bog acquired by the Ontario Peat Fuel Company (Limited) is situated in the townships of Humberstone and Wainfleet, in the county of Welland, and comprises an area of about 5,000 acres, principally in the second, third and fourth concessions of those townships. The company has erected a plant on lot 9 in the third concession of Wainfleet, with the view of engaging in the manufacture of both moss-litter and peat fuel. The estimated capacity for the former is 30,000 tons and for the latter 75,000 tons per annum. The upper layers of the moss, consisting of undecomposed vegetable material suitable for litter, extend over the whole surface of the property to a depth of about two feet, and it is estimated will furnish about two million tons of the finished article. The process of manufacture is patented, and, after the first cutting up and removal of the moss from the bog, involves very little manual labor. The material is dried by a new process, which is not subject to interruption from wet weather, and can be carried on at all seasons of the year except in the severest winters. The process used to expedite the drying also very greatly shortens the time of manufacture, the completed article requiring not more than an hour for its production. The litter from this bog is said to be quite equal to the Dutch or German article, the color being bright, the quality fibrous and the absorbent powers high. The company has had no difficulty in contracting for the sale of an average output of 22,000 tons a year for five years in United States markets. Considerable quantities of moss-litter are used by large horse-car and other companies in New York and the larger American cities, which is imported exclusively from Europe, and there seems no reason why an article equally good and comparing favorably in cost from the Welland bog cannot be made to replace these European importations. An important home demand is also expected to arise when the merits of the litter become known.

Process of manufacture.

The market for moss-litter.

The retail selling price in New York varies from $7 and $8 a ton upwards, according to quantity taken. In London the price in 1894 was 32 shillings a ton, which is said to have been an advance of about 50 per cent. over the current rates at the beginning of 1893. The company will put up the litter in tightly pressed bales of 225 lb. each, or eight to the short ton, bound with wire.

[15] For fuller description of moss-litter and the methods of its manufacture and use, see articles on The Utilization of Peat, Report Bureau of Mines 1892, p. 195, and Moss-Litter, Report 1893, p. 139.

Shipping facilities from Welland.

The shipping facilities at the manufactory are good, the plant being situated within 1,000 feet of the Welland canal, and a mile and a half from lake Erie, with the line of the Buffalo and Lake Huron railway intervening. The Grand Trunk and Michigan Central railways are two and three miles distant respectively, and arrangements are being made with both companies to run spur lines to the manufactory. The company has also acquired the right to build a wharf and exercise shipping privileges on the canal.

Fuel value of the lower beds of the peat.

Below the mossy surface of the bog a heavier and more compact peat extends to a depth of four to twenty feet. It is the intention of the company to manufacture a compressed fuel by the Dickson patented process from this portion of the bog. By the Dickson method it is stated that the raw material can be converted into the finished article within a few minutes from the time it is dug up, and without the application of heat. The resulting fuel has a density of 93 lb. per cubic foot, or almost equal to that of anthracite coal. As the surface of the bog becomes converted into moss-litter the lower portions will be laid bare and the two operations can be carried on at the same time. Mr. A. A. Dickson is president, and Mr. J. R. Silliman secretary of the company, whose head office is in Toronto.

SECTION II.

GOLD IN ONTARIO: ITS ASSOCIATED ROCKS AND MINERALS.

By Dr. A. P. Coleman, Geologist and Mineralogist of the Bureau.

Since the discovery of the Richardson mine in the township of Madoc, in 1866, gold has been found at hundreds of points in Ontario, from the Madoc region in the east to the Lake of the Woods in the extreme west. In this distance of 900 miles there is nowhere a gap of more than about 100 miles between known gold deposits, except in the little explored region northeast of lake Superior, where gold has not been discovered for a stretch of 175 miles. It will be convenient to speak of three gold regions in the province, a southeastern one in Hastings county, a central one reaching from Wahnapitae to the Sault, and a western one extending from lake Shebandowan to the Lake of the Woods. A few isolated discoveries lie outside these areas, and it may be that future finds will connect the three gold regions into a single one, including the whole Archæan portion of Ontario.

Gold regions of Ontario.

Unlike most gold regions, Ontario has no placer deposits, a consequence of intense glacial action which has swept away all gold bearing sands and gravels and so mixed them with barren materials in the immense beds of drift found in the southern portions of the region as to make placer mining hopeless. It is said that colors of gold may be washed from the sands of Toronto island, and probably traces of placer gold could be obtained at many other points by perseverance in panning, but nowhere in paying quantities. In this respect Ontario resembles Nova Scotia and differs from Quebec with its Chaudiere placers, and still more from British Columbia.

Effects of ice action on gold occurrences.

Another important result of ice action has been the more or less complete removal of weathered products from the surface of veins, so that the sulphides which regularly accompany gold-bearing quartz in all parts of the world below water level are here found as a rule only a short distance beneath the surface; implying that no large amount of thoroughly free milling oxidized ore can be obtained from our mines, and that the more refractory sulphide ores must be treated from the very first. The points just mentioned account largely for the slow advance of gold mining in the province.

The gold from our mines is unusually pure, resembling in this respect the gold of Nova Scotia rather than that of British Columbia. Assayers notice that Ontario gold ores, when free from galena or copper pyrites, yield buttons with little more silver than is accounted for as coming from the litharge or test lead employed in the assay. Probably the proportion of silver is generally less than five per cent., though exceptions occur to this rule. Dr. Lawson states that in some gold ores from the Lake of the Woods

Purity and form of the gold.

"silver occurs in the auriferous quartz veins, generally as an accessory mineral, in small quantities, but sometimes, as the assays of the Pine Portage mine show, in greater proportion by weight than the gold." [1]

Our gold appears in the usual forms as nuggets, scales, etc., and never, so far as I have observed, in crystals, though crystals of gold have been reported from the interesting new region of Wahnapitae. Specimens from that lake in the museum of the School of Practical Science, Toronto, show smooth planes, but apparently only an impress from adjoining quartz crystals.

Minerals Associated with Gold.

Quartz and its characteristics.

Of the minerals associated with gold quartz is by far the most constant, so that miners and explorers are apt to call every gold ore, no matter what its composition, quartz; if, indeed, they do not refer to as a "quart," with the idea that a single specimen should be spoken of in the singular, not in the plural. The gangue quartz of Ontario gold ores varies greatly in character. Often as found at the surface it is rusty and porous, "good looking rock," while a short distance below it contains sulphides and is quite different in appearance. The quartz may take on crystal form and be more or less clear and transparent, as in some specimens from Wahnapitae; or it may be massive or bluish-gray, as in the ore from the Ophir mine in Galbraith township, or the Sultana mine near Rat Portage. Some of the latter quartz, which is distinctly schistose and has a crypto-crystalline appearance with thin bands of chlorite or hornblende running through it here and there, might properly be described as quartzite. In other regions the quartz is apt to be fine grained and milky or dull white, as at the Partridge mine near the Atik-okan, or the Ledyard mine in Belmont. From the latter locality come some beautiful specimens of white cellular quartz with specks of gold disseminated over the walls of the cells. In the same quartz Mr. McAree has observed small red jaspery concretions.[2] Sometimes the quartz is stained to a pale red with films of hematite, as at the Ray-Wiegand mine on the Seine river, or green with malachite, as in the McGowan mine near Parry Sound.

In texture then the quartz may form crystals or coarse or fine-grained crystalline masses, or it may be crypto-crystalline and compact. Its color may vary from pure white to greenish-black, or it may be stained red or brown or green with iron or copper compounds. It may be almost transparent, or only translucent, or quite opaque. It may be true vein quartz, or a schistose quartzite. A few other oxides occur in our gold ores, especially the brown hydrous and the red anhydrous oxides of iron in weathered surface ore. Vennor states that gold has been found embedded in the third oxide of iron, magnetite, in the Madoc and Marmora district, and that Prof. Bell of Albert College, Belleville, found oxide of tin in a specimen of ore from the same district.[3] A similar association has been observed at the Vermilion mine in the Sudbury region, where small amounts of cassiterite occur.

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[1] Geol. Sur. Canada, 1885, p. 143 CC.
[2] Papers of Engineering Society, S. P. S., p. 26, etc.
[3] Geol. Sur. Can., 1871-2, p. 131.

Sulphides of one kind or another are almost universal accompaniments of ores of gold that have not been subjected to weathering, the most prominent of course being iron pyrites, whose brassy gleam may be seen in most of our gold ores. It displays the usual crystal forms, cubes with striated planes or pentagonal dodecahedra. Crystals an inch in diameter are sometimes found in the Belmont ores. The common occurrence of pyrite with gold is no doubt accounted for by the mode of transport and deposit of the metal, sulphate of iron having the power to dissolve small quantities of the metal. Any reducing agent, such as organic matter, destroys the solvent by forming sulphate of iron, the gold being deposited at the same time. This theory satisfactorily accounts for the particles of gold often found embedded in the pyrite. If the particles are above a certain size they are more or less completely liberated by crushing, and may be saved by amalgamation. Such sulphide ores are partially or wholly free milling. If the particles are very minute many of them will not be set free by simple crushing, and the ore is refractory. It is worthy of note that some of our ores which have been looked on as highly refractory, so that thousands of dollars have been spent on chlorination or other plants with which to treat them, have turned out to be almost completely free milling. An excellent example of this is to be found in the Sultana mine, from whose sulphide ores $92\frac{1}{2}$ per cent. of the gold is extracted in the stamp mill, and the small quantity of concentrates obtained hardly pays for treatment.

Sulphide ores.

Iron pyrites.

In the Sultana ore one frequently sees specks of gold embedded in the quartz entirely apart from the iron pyrites. It is clear that this gold cannot have been deposited in the way suggested above. Perhaps this and the nuggets sometimes found in pure white quartz at the neighboring Ophir mine have been carried in the form of a gold silicate, as suggested by Bischoff and other writers.

The cellular white quartz from Belmont doubtless once had its cavities filled with pyrite crystals like those now found below the level of weathering. The sulphide has been oxidized into sulphate and leached out, one stage of the process being perhaps the formation of hydrous sesquioxide of iron and of siderite.

I am not aware that the marcasite variety of iron pyrites has been found in our gold ores, but pyrrhotite, the lower sulphide, is not infrequent in the Lake of the Woods region.

Small amounts of copper pyrites are often found accompanying the iron pyrites in our gold quartz, sometimes largely replacing it, as at Oliver Daunais' Wabigoon mine. The other copper sulphides, bornite or peacock ore, and chalcocite or copper glance, are much less common. In one very interesting deposit found last spring near Parry Sound these two minerals occur in large quantities in the quartz, far outweighing all the other sulphides, and small nuggets of gold may be enclosed in them or lie between the copper ore and the quartz.

Copper pyrites.

Mr. Coste in his report on the Lake of the Woods region mentions the somewhat rare sulphide of copper, covellite, as occurring with iron and copper pyrites, bornite and other sulphides in the gold ores from that part of Ontario.[4]

[4] Geol. Sur. Can., 1882-4, p. 15K.

Galena and zinc-blende.

The only other sulphides which I have observed or seen mentioned in connection with our gold ores are galena and zinc-blende. The former is often found at the Lake of the Woods and Rainy lake, and is there considered a favorable sign, since it is generally associated with free gold. The cause of this relationship is not easy to understand, for the galena itself does not usually carry any important amount of gold. Zinc-blende is found in small quantities in mines near Port Arthur and Marmora, but seems to have little influence on the gold contents of the ore. The sulphides of iron and copper seem much more efficient as gold bearers than those of the other metals.

Mispickel and tetrahedite.

The only compounds of arsenic or antimony found in our gold veins are mispickel and tetrahedrite. The latter mineral has been reported from only one locality, so far as I am aware, the Empire mine in Madoc, where Vennor found it forming small gold-bearing veins with calcite, magnesite and quartz in dolomite [5]. Mispickel, on the other hand, is rather widely spread in the gold deposits of the province, being found in small quantities in ores from the Lake of the Woods, and in immense amounts at the Gatling and other mines near Deloro in Marmora. The mispickel of Deloro occurs sometimes as very pretty rosette-like twinned forms or as crystals of prismatic habit, but more commonly in fine or coarse-grained masses. According to Prof. Chapman [6] it averages from one or two to seven or eight ounces per ton of gold, and the value of the ore is considerably increased by the large amount of arsenic it contains ; but the ore proved so refractory that the expenditure of hundreds of thousands of dollars in elaborate reduction works resulted only in failure.

Rosette.

A quite similar ore was worked, apparently at a profit, many years ago at Goldberg, in Silesia, where the arsenic was made a valuable part of the output. It is probable that improvements in method may yet cause these mines to be valuable. In considering the province as a whole, one should remember that arsenic in amounts sufficient to make the ore very refractory is confined to this narrow belt of territory. The Belmont mines, a few miles away, show no trace of mispickel.

Sylvanite and other minerals.

Tellurium occurs, apparently in only one locality in the province, in the sylvanite of the once famous Huronian mine west of Port Arthur.

The other minerals associated with gold in the province are not specially important. Free gold may sometimes be found in the silicates forming the wall of veins. A pretty specimen from Wahnapitae, now in the museum of the School of Practical Science, Toronto, contains several small nuggets completely enclosed in green chlorite. Vennor refers to the occurrence of gold in dolomite and calc spar, [7] and describes the wonderfully rich cavity of the Richardson mine in Madoc, where the first gold was discovered in Ontario. The gold was here found in a " reddish brown ferruginous earth in which were scattered fragments of a black carbonaceous matter, the latter showing when broken small flakes and scales of the metal." [8] Specimens of free gold

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[5] Geol. Sur. Can., 1866-69, p. 168.
[6] Minerals and Geology of Central Canada, p. 307.
[7] Geol. Sur. Can., 1866-69, p. 167.
[8] Ibid., p. 165.

from Marmora, in the School of Science collection, are associated with a somewhat weathered siderite. Probably some of the rusty quartz with free gold from this and other parts of the province results from the decay of siderite or other carbonates rich in iron rather than from the weathering of sulphides.

THE GOLD-BEARING FORMATIONS.

Laurentian,

Turning now to the rocks in which the gold deposits of the province occur, we find that they are all very ancient, most of them Archaean. The south-eastern region, that of Marmora, Madoc, Belmont and other townships, is probably the most ancient, belonging to what Vennor calls the Hastings series, believed by him to be the equivalent of the lower Grenville series of Logan, *i.e.*, to the lower portion of the upper division of the Laurentian. It is possible however that these rocks are really a small area of greatly modified Huronian. The remarkable gold-bearing deposit of Parry Sound is probably of the same age. All the other important gold districts are Huronian, if we assume that Lawson's Keewatin is in reality of that age.

Huronian,

and Keweenian.

Dr. Chapman however has obtained gold from a vein in Keweenian rocks at the Enterprise mine on Black bay, lake Superior; and gold has been found in the Animikie, north and east of Port Arthur, [9] showing that the precious metal does occur in rocks younger than Huronian, probably Lower Cambrian.

Eastern region.

Lithologically, the rocks in which gold has been found in Ontario vary greatly. Vennor describes the famous Richardson mine as occurring at the contact of a "chloritic and epidotic gneiss with a silicious ferruginous dolomite." It was in a cavity at this contact that the thousands of dollars worth of rusty earth thickly spangled with flakes of gold were found, which roused a gold fever the like of which has never been experienced since in the staid province of Ontario. In several other parts of the Hastings series Vennor finds gold in veins running through dolomite, in silicious dolomite or at the contact of mica slate and dolomite. With the dolomite are mentioned various schistose rocks, talcose, micaceous, chloritic and hornblendic. So far as mining experience goes in Hastings, the deposits in connection with dolomites are merely pockets, sometimes rich, but quickly exhausted. Vennor believes that the gold of the region is in close association with the summit of an iron bearing band.

The only specimens of country rock from the region which I have examined are from the Belmont mine. The specimens, which are greatly weathered, consist of diorite, perhaps originally diabase, and chloritic schist. The latter contains a large amount, almost 50 per cent., of a carbonate, calcite or dolomite. Mr. McAree, who examined the country rock of the Crawford mine in the laboratory of the School of Science, found it to be weathered diorite, with chloritic schist in the walls.[10]

Central region.

Passing to the central gold region, the rocks containing the gold deposits about lake Wahnapitae have, so far as I am aware, never been carefully examined, though Bell maps them as Huronian with eruptive masses of

[9] Min. and Geol. Central Canada, p. 301, etc.
[10] Papers of Eng. Soc., S.P.S., p. 26, etc.

diabase and diorite, the Huronian being defined as consisting of a variety of crystalline schists and strained clastics, such as greywacke. The country rock of the Vermilion mine is Huronian, but of just what character I am not aware.

A specimen of the country rock of the Ophir mine in Galbraith township, submitted to me by Mr. Blue, Director of the Bureau, though greatly weathered, is pretty certainly a diorite.

Western region.

Going still farther west we find some gold-bearing veins in the dark Animikie slates north and west of Port Arthur. No doubt the eruptions of fine grained diabase which traversed these rocks and covered them with wide-spread beds of lava have had a great influence on the formation and filling of the gold veins, as well as those of silver, in the region.

The Huronian mine, unique in Ontario as containing the rare mineral sylvanite, doubtless occurs, as its name suggests, in the Huronian, but I have not seen any detailed description of the enclosing rocks. The country rock of the gold bearing veins to the west of this is generally Keewatin (Huronian) or Laurentian near the contact of Keewatin, the only exception being the Shoal lake district, where the gold occurs in granite.

REPORT ON THE RAINY LAKE GOLD REGION.

Having been appointed Geologist and Mineralogist to the Bureau of Mines of the Province of Ontario in January, 1894, I was instructed by the Director, Mr. Archibald Blue, to prepare for a summer's work in the Rainy Lake gold region. Dr. John Burwash of Victoria University, Toronto, formerly Mineralogist to the Province of New Brunswick, was appointed my assistant. The necessary instruments were obtained, the Rice Lake canoe belonging to the Bureau of Mines was handed over to us, and, all preparations having been made, we left Toronto on June 17th for Rat Portage.

Outfit for the summer's work.

Here another built canoe was bought, our camp equipment was completed, and William Margach, jr , was engaged as canoeman. After two or three days spent in visiting the Sultana mine and other points of geological interest in the neighborhood, we took the steamer Monarch for Fort Frances,[11] and there completed the party by engaging two half-breeds, John Vincent and Pierre Mainville, as cook and canoeman.

Outlines of the field explored.

Sand Point island was made a base from which to study the geology of the central part of Rainy lake with some detail, so as to become familiar with the characteristic rocks with which we were to deal. Seine bay and the Seine river with its expansions, Shoal and Wild Potato lakes, were traversed as far as Sturgeon Falls. Bad Vermilion lake was next taken up, and then following Little Turtle lake and Sand Island river, we returned through Redgut bay to Rainy lake. Crossing by Grassy Portage and other bays, the two new townships of Halkirk and Watten, then under survey, were examined, and the party returned to Fort Frances on the 18th of July.

[11] Often, but erroneously, written Fort Francis. In a letter to Mr. J. F. Whitson of the Crown Lands surveys branch, dated January 18, 1894, Mr. Jabez Williams, H. B. Co. factor, says: "Fort Frances is named after Lady Frances Simpson, wife of Governor Sir George Simpson, who used to pass by this route on his trips of inspection of the company's posts."

During this canoe trip nearly all the gold mining locations of this part of the region were visited, studies were made of the veins and country rock, and specimens collected for further examination.

After a day or two spent in refitting and in visiting the new stamp mill at Rainy Lake city, Minnesota, which was working on ores from the Little American mine, the first mine in operation on the lake, we turned northwards, passing through Northwest bay, lake Despair and Clear Water lake to Pipestone lake. From this point we turned eastward, over Strawberry and other lakes, to the southwestern end of lake Manitou. The mining locations on the upper portion of the last lake were examined, and passing through a chain of small lakes we reached, on August 14th, the Canadian Pacific railway at Wabigoon. Here the two half-breeds were paid off and returned to Fort Frances with a bark canoe, while the rest of the party returned to Rat Portage by rail. The party now disbanded, Dr. Burwash returning to Toronto, while I undertook a number of small expeditions, visiting several of the mines on the Lake of the Woods and near Rossland.

I then proceeded to Savanne with one of the canoes and, engaging a white man and an Indian as canoemen, made a rapid journey via Lac des Milles Lacs and other lakes to the Atik-okan river. It was my intention to go on to the gold mining locations on the upper Seine, but forest fires and the exceedingly low water in the creeks hampered the work so much that the trip was cut short at Osinawe lake, and I returned to Savanne, reaching it on September 1st. On the way home to Toronto I visited some of the famous iron mines of Minnesota and copper mines of Michigan.

Except for unusually high water on Rainy lake early in the summer, which covered many interesting outcrops along shore, and low water toward the end, interfering with canoe navigation, as well as the too prevalent forest fires, the season was a particularly favorable one for geological work. The men employed, both whites and Indians, proved good and efficient.

Lawson's Report on the Rainy Lake region.

In studying the mineral resources of the Rainy lake country, we found one work indispensable, Dr. Andrew C. Lawson's Report on the Geology of the Rainy Lake Region, Part F of the annual report of the Canadian Geological Survey for 1887. It was constantly in our hands while we were in the region it covers, and it has been made use of very often in the preparation of the following report. Dr. Lawson's work was of a singularly able and original character, and, while all his conclusions may not turn out to be correct, the fresh points of view which he suggests and the careful and accurate observations which he records are of great value to a geologist working over the same ground. The map accompanying his report and embodying its results is admirable, both from the geological and the topographical point of view, and is highly appreciated by every one having occasion to visit the country as explorer, steamboat captain, tourist or geologist. The sheet is unfortunately on rather too small a scale, four miles to the inch,[12] but still is clear and well executed, so that a guide is almost unnecessary on the routes which it covers. The geological coloring of the

[12] The Lake of the Woods sheets, published in 1885, and prepared by Lawson and his assistants, are on the scale of two miles to the inch, which gives room for greater geographical detail.

map is, according to our experience, very correct along the water courses, though a few comparatively unimportant points are corrected in the following report. Inland, where the country is inaccessible by canoe, the outlines of the areas covered by the various rocks are of course somewhat hypothetical, and will no doubt need minor adjustments.

Russell's map of the Manitou and upper Seine regions.

For portions of the mining region, like the Manitou country and the upper Seine river, which extend beyond the limits of the sheet, the maps published by Mr. A. L. Russell of Port Arthur are very useful, giving the canoe routes and surveyed locations. Mr. Russell's maps do not, I believe, cover the upper Manitou, and one must have recourse to tracings from the map in the Ontario Crown Lands Department, which covers all that has been surveyed, and gives also those parts of the shore line which were mapped by the Geological Survey some years ago in preparation for a new sheet of the geological map not yet published. Up to the present the Geological Survey of Canada has published two sheets of the Lake of the Woods region, the Rainy Lake sheet, and a sheet just to the southeast, embracing Hunter's island and adjoining portions of Ontario to the east and west. Dr. G. M. Dawson, Director of the Geological and Natural History Survey, has been kind enough to inform me that the sheets, including lake Manitou and the Seine river east of Wild Potato lake, with some others, are under way. It is to be hoped that under the vigorous new director we shall soon have geological maps covering the whole of this part of Ontario, which is so interesting and important from the economic side.

Winchell and Grant's Report.

Much of the present report was written before "A Preliminary Report on the Rainy Lake Gold Region" by H. V. Winchell and U. S. Grant of the Geological Survey of Minnesota[13] was received; but advantage has been taken of it to add some points of interest to the account of the Little American mine and the Shoal Lake mining camp. A useful geological map, mainly taken from Lawson's, adds much to the value of their report.

Acknowledgments.

The writer of the present report wishes to express his gratitude to the many friends who have aided in the work, officials of the Crown Lands Department of the province, members of the Hudson Bay Company at Rat Portage, Fort Frances and Savanne, and many miners and prospectors; the latter, generous and hospitable men, rarely overburdened with this world's goods, but perennially hopeful for the future. They are a class who are of much importance to the province, and yet who seldom reap the full reward of their labors and privations.

The Geography of the Region.

The field, and ways of reaching it.

The newest gold region of Ontario, that of Rainy Lake, lies east of the Lake of the Woods, south of the Canadian Pacific Railway, west of Lac des Milles Lacs and north of the Itasca and St. Louis counties, in Minnesota. It may be reached by a week's hard paddling from Port Arthur, by four or five days' canoeing from Savanne, or by two or three days from Wabigoon down the Manitou route, as well as from other points on the railway; but the

[13] Part III of the Twenty-third Annual Report.

easiest route in comfort of travel and the shortest in time is by the Canadian Pacific to Rat Portage and thence by steamer through the beautiful Lake of the Woods and up the charming Rainy river to the head of navigation at Fort Frances. Once above the fall of 22 feet at this point, about two and a half miles of journey bring one to Rainy lake. If the unfinished lock at Fort Frances were completed there would be uninterrupted navigation from Rat Portage to Sturgeon Falls on Seine river, about 50 miles east of the fort. The trim and beautifully placed village of Fort Frances and its less finished neighbor, Koochiching, across the river in Minnesota, are connected by small steamers with Rainy Lake city fourteen miles to the east, on the southern shore of the lake near the Little American mine. The lake may also be reached from Duluth and other points to the south by taking a train to Tower and then traveling north by stage and water to Rainy Lake city; but this route is not a favorite even for Americans, many of whom come round by Port Arthur and Rat Portage.

The gold region as a whole is almost entirely included in territory reached by Rainy lake and its tributaries, Manitou river and lake to the north, and the Seine with its lake expansions to the east; so that Fort Frances is the natural starting point for prospectors and explorers. The heavy machinery of the stamp mill at Rainy Lake city came in via Rat Portage and Fort Frances. It is but a question of time however when railways will enter the region from the south, and perhaps also from Port Arthur on the east. By utilizing the water-power of Seine river an electric railway is one of the possibilities.

Physical characteristics of the country: the Land of a Thousand Lakes.

The general physical characteristics of the country are similar to those found in other glacier swept Archæan tracts, such as Muskoka and the Thousand Islands. In contrast with the latter one might call the region as a whole the "Land of a Thousand Lakes," giving a wider application to the poetical name attached by early French explorers to a body of water lying to the east. It is a land of innumerable lakes, with unnumbered bays and islands. Rainy lake is of course the largest, reaching 25 miles north from its outlet near Fort Frances, and nearly 40 towards the east. Its general shape is that of a capital L with an exceedingly ragged outline. The lake scarcely anywhere presents a stretch of more than ten miles of open water, and yet its coast line, without counting minor indentations, is probably at least 600 miles, or more than that of lake Ontario, and if one included the shorelines of its islands, probably the mileage would be almost doubled. The other lakes of the region, like the Manitou and Pipestone, though much smaller, imitate Rainy lake in their endless channels, inlets, sounds, straits and ramifying bays; so that the complication of land and water is most puzzling to the explorer. It is probable that within the region covered by Lawson's Rainy Lake sheet, 50 miles by 75, there are thousands of miles of shoreline. Along most of these shores the rock is well exposed, so that conditions could hardly be better arranged for the work of the geologist and prospector. There are however a few lakes, such as Furlonge, where the woods come right down to the shore,

Favorable conditions for exploration.

and rock is rarely to be seen; but in many cases rocky slopes or walls rise directly from the water, so that much may be seen without even getting out of the canoe.

Forest fires.

Inland the case is different. Soil and forest growth cover the surface, and rock crops out only here and there as weatherworn ridges, unless, as is too often the case, fires have swept off the Norway and white pine, leaving a tangle of fallen trunks upon the calcined surface. A second visitation of fire, as at some points on the shore of lake Manitou, may sweep off soil, fallen timber and all, leaving bare slopes and crests of rock which will probably not be covered with vegetation for generations to come. These fires, though to a certain extent helpful to the prospector, must in the long run be very injurious to the country as a mining region, robbing it of the timber necessary for fuel, as well as for building and mining purposes.

Dr. Lawson graphically describes this "rocky lake country" in an early part of his report, and points out the fact remarked by every observer that it consists of a series of larger and smaller rock-rimmed basins each spilling over into the next lower. These chains of lakes make an ideal region for canoe navigation, and they are so numerous and the water-sheds so narrow that with a little management and a few long portages one can paddle across country in almost any direction.

An ideal region for canoeing.

The basin of Rainy lake a weathered and ice carved plain.

Lawson puts the level of Rainy lake at about 1,182 feet above the sea. The deepest sounding which he obtained is 110 feet, and he speaks of the highest point, in the Kishkutena ridge, as 600 feet higher.[14] The region as a whole, in spite of its variety of surface, contains nothing that can be described as a mountain, and must be looked on as an ancient base-leveled surface, a plain whose contorted and unequally resisting rocks have been weathered and ice carved into the present confusion of hills and water filled hollows. Confusion is however an unsuitable word, for Lawson has pointed out that the longest axis of the ridges as well as of the lakes conforms to the strike of the schists, wherever they are exposed, and that it is only in the granite and gneiss, where a schistose structure is not marked, that lake forms are quite irregular. Here as everywhere the topography has a foundation in the geology of the country.

Waters and fish of the lakes.

The water of Rainy lake and many of its satellites is brownish and rather turbid, though not unwholesome. To me it appeared to have a rainy taste, perhaps explaining the origin of the name. Its waters contain whitefish, pickerel and jackfish, but not trout. Manitou and Clearwater, as well as several other smaller lakes, have exquisitely clear water and are the home of fine trout. A few of the smaller lakes are silting up and filling with mud and weeds, so that every stroke of the paddle stirs up a swarm of foul bubbles.

Areas of rich bottom lands.

While most of the district is of the rocky lake type just described there are a few portions covered by alluvial clay, where there is level fertile soil, once lake bottom, now more or less perfectly drained by winding sluggish rivers here and there expanding into marshy lakes. The largest area of good land is found, as is well known, along Rainy river, but considerable tracts

[14] Geol. Sur. Can., 1887, p. 11F.

occur along the Seine and parts of Turtle river. In such parts of the country the smaller creeks loose themselves among pond lilies and weeds, favorite feeding grounds of the increasing moose; and canoeing becomes slow and toilsome, while outcrops of rock are few and far between. Many of the small bands of Indians, mostly pagans, who thinly people the country have their reservations on these rich bottom lands.

All the waters of the district under consideration empty finally into Red river, and thus reach Hudson bay.

General Geology of the Rainy Lake Region.

For a detailed account of this subject the reader is referred to Dr. Lawson's report, where some very difficult but interesting problems relating to the Archæan are attacked in a bold, original way, and the results of careful observations are described, giving a basis of facts to support his views. For our purpose however an outline sufficient to make the work that follows intelligible is all that is required.

Divisions of the Archæan formations.

The whole region belongs to that most ancient of formations, the Archæan, which Lawson divides up as follows:[15]

$$\text{Archæan}\begin{cases}\text{Upper division.} & a.\ \text{Keewatin. (Huronian ?)} \\ & b.\ \text{Couchiching.} \\ \text{Lower division.} & \quad\text{Laurentian.}\end{cases}$$

The Lower Laurentian, and its characteristics.

In eastern Ontario the Laurentian has been divided into a lower series, the Ottawa gneiss, and an upper one, the Grenville, which contains crystalline limestones. Only the lower series is represented in the Rainy Lake region, where the Laurentian consists of various granitic and gneissoid rocks. The granites contain quartz, felspar, chiefly orthoclase, and biotite, the black variety of mica, or instead of biotite, hornblende. In most cases the granite seems to merge at one point or another into gneiss, consisting of the same ingredients. The foliation or schistose structure of the gneiss is often not very marked, and the rock may then be called a granitoid gneiss. The quartz of the granite may be absent more or less completely, when the rock becomes syenite with the corresponding gneissic form. This series of rocks varies from quite fine grain to very coarse; and in many cases the orthoclase felspar forms large oblong crystals, often Carlsbad twins, imbedded in a finer grained ground mass, so that the rock becomes porphyritic. In color these rocks vary according to the tinge of the felspar and the amount of the dark minerals, biotite and hornblende, so that all gradations from almost white to dark gray occur, the general tone being reddish.

Couchiching Series.

Couchiching series of the Upper Archæan.

Resting on the Laurentian toward the southern part of Rainy lake we find a series of monotonous rocks which Lawson has named Couchiching,[16] gray cleavable schists consisting of quartz and fine scales of mica, with or without felspar; in the latter case forming gneiss. These fine grained, dull gray or brownish, very cleavable mica schists and gneisses are generally easily distinguished from the granitoid gneisses of the Laurentian; Lawson considers this

[15] Geol. Sur. Can., 1887, p. 22 F.
[16] Ibid. p. 99 F., from the Couchiching rapids near Fort Frances.

group of rocks to be a series of sediments which have undergone alteration. They often contain garnets and other minerals, suggesting metamorphism. Lawson assigns a thickness of about five miles to the Couchiching series.[17]

KEEWATIN SERIES.

Above the Couchiching, where the latter is found at all, comes the series of rocks, probably Huronian, named by Lawson Keewatin.[18] The majority of them are green, but some are pale yellow or brown. Among the green rocks there are massive beds with no tendency to cleave in one direction more than another, so that they may be looked on as traps or greenstones, in reality more or less metamorphosed diabases having the ophitic structure of slender prismatic felspars, or less often the granite type of basic rock, gabbro. One can rarely see the twin striations on the felspars of these rocks, so decomposed are they; and the augite which forms the other chief constituent is generally changed to some chloritic mineral or hornblende. In the field the diabases and gabbros are often hard to diagnose, so that the term greenstone is allowable for these hard, dark green, massive rocks. They appear to pass into somewhat schistose portions, probably the result of pressure and shearing forces acting on originally massive beds. Another more schistose group is considered by Lawson to be of sedimentary origin, probably altered volcanic ashes. They form soft, often lustrous, chloritic schists with a little quartz or felspar or some carbonate between the layers of chlorite scales; or hard green hornblendic schists, or a mixture of the two, the hornblendic variety prevailing when near the contact with the Laurentian. In a few cases the Keewatin seems to form a dark mica schist close to the granitoid gneiss. The massive beds of greenstone are often interbedded with these schists. Conglomerates, fine-grained to very coarse, containing rounded pebbles or stones of various materials such as quartz, greenstone, gneiss or quartz porphyry, are associated with the green schists in some places, apparently as basal beds. The matrix in which these pebbles are imbedded is green schist like that just described, the layers of chlorite or hornblende folding closely round the included stones. It is clear that when these conglomerates were laid down there were sea-washed shores on which solid gneiss and other rocks were worn and rounded just as they are to day. The boulders themselves have pretty successfully resisted the subsequent metamorphic influences, while the clayey cement, perhaps partly volcanic ash, has been changed into green schist.

Character of the Keewatin rocks.

Schists and conglomerates.

Greywacke and talc.

In some parts of the Keewatin greywacke occurs, a dull gray or greenish-gray rock made up of irregular angular fragments of quartz and other minerals. A greenish-gray impure talc, soft enough to be scratched by the thumb nail, is found in a few places, as at the upper end of Pipestone lake, a material long used by the Indians of the region for carving into pipes.

Upper section of the Keewatin.

An upper section of the Keewatin is quite different from this lower basic series of greenish rocks. The second group consists of pale yellowish or brownish or flesh-colored rocks, an acid series rich in silica or quartz. The commonest forms are felsite schists, very fine grained, easily cleavable rocks, consisting mainly of quartz, unstriated felspar and minute scales of pale mica

[17] Geol. Sur. Can., 1887, p. 102 F.

[18] Ibid. 22 F, etc.

sericite or muscovite). Little fragments of quartz and crystals of felspar can sometimes be distinguished in the fine grained ground mass, reminding one of an eruptive rock, quartz porphyry. Lawson supposes that the once massive porphyry has been sheared or squeezed into the very cleavable felsite schist. In some instances there are masses of undoubted quartz porphyry enclosed in the schist, perhaps more resistent portions of the original rock. The pale acid (or silicious) rocks are often closely intermingled with the green basic ones, a layer of the one being followed by a layer of the other, and so on alternately. Lawson looks upon these pale Keewatin rocks as the result of a second set of volcanic eruptions, the more acid lava flows following the basic eruptions which gave rise to the beds of greenstone and chlorite schists so generally characteristic of the Keewatin.

Thickness of the series.

Lawson determines the thickness of the Keewatin beds to be about five miles, judged by a section near the lower end of Manitou lake. W. H. C. Smith, in his report on the Hunter's Island district, concludes however that

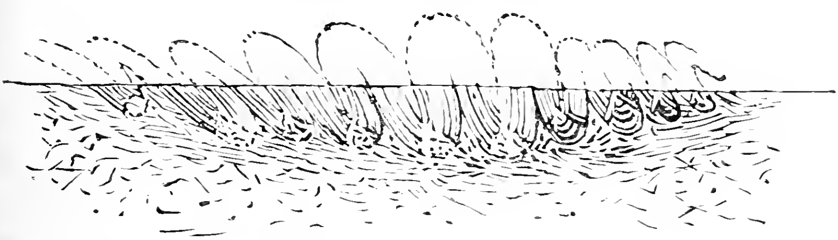

Fig. 1. Folds in Couchiching—after W. H. C. Smith, p. 55 G, Geol. Sur. Can., vol. V., Part 1

the Couchiching beds, in one place at least, have been thrown into numerous folds, which have been squeezed together so that a section across their eroded edges gives a quite false idea of the original thickness,[19] and it is possible that the same may apply to the Keewatin.

RELATIONS OF ARCHAEAN ROCKS.

Arrangement of Laurentian and Huronian areas.

The geology of the region, as worked out by Lawson, shows very interesting relations between the rocks just described. The granitoid gneiss and other members of the Laurentian occupy wide areas, having rounded outlines, and in most cases the foliation, i.e., the direction in which the mica or hornblende plates are arranged, is parallel on all sides to the margin of the area. Stretching around these Laurentian areas we find the Huronian rocks in narrow bands, enclosing the gneiss in a wide meshed network. Where two strands of Keewatin come together in the network they spread out into curves, so that the points of junction are the widest parts of the bands. The foliation of the Huronian schists is generally parallel to the adjoining edge of the gneiss. The "strike" of the schists, the direction of their cleavage, changes from point to point as the band of Keewatin curves round the areas of gneiss.

Attitude of the green schists, and

The attitude of these green schists is remarkable. They hardly ever lie level or nearly so, but are almost always steeply tilted and often vertical. In most parts of the region the green schists come directly in contact with the

[19] Geol. Sur. Can., 1890-91, p. 55 G.

gneissoid rocks, but along the southern shores of Rainy lake and the Seine river wide bands of the gray Couchiching mica schist or gneiss intervene between the Keewatin and Laurentian. In the northern part of the region and on the shores of the Lake of the Woods the Couchiching appears to be absent. If the schistose layers of the Couchiching and Keewatin represent an original bedding of volcanic ash and other sediments laid down in water, and not a structure imposed on them since by earth movements, we must suppose that these beds once lay nearly horizontally on the rocks beneath. How comes it that we now find them usually on end? Lawson has a daring explanation of this state of affairs. The underlying rocks, gneisses or whatever they were in the beginning, were deeply buried by the rocks above, became gradually softened by heat from the earth's interior, until they formed a plastic or even fluid mass which rose in huge swellings, lifting the Huronian in some places and in others nipping the beds into sharp downward folds between the swellings. That the molten or semi-molten gneiss penetrated the schists, and carried off great fragments of them at their edges, Lawson has conclusively proved, and the evidence is clear to any observer among the islands of the

Lawson's theory as to the origin of it.

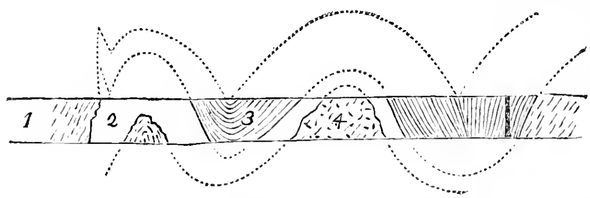

Fig. 2. 1, Gneiss; 2, Couchiching; 3, Keewatin; 4, Granite. Folds of Couchiching and Keewatin—after Lawson.

central part of Rainy lake. This is such an astounding thing, especially on the scale presented in this region, that the present writer paid special attention to the point, and believes that Lawson's explanation is correct.

The Keewatin schists older than the Laurentian.

If we date the age of a rock from the time when it solidified, the Keewatin schists, generally considered Huronian, must be older than the underlying Laurentian gneisses, which were fluid enough to carry off blocks of the already solid green schist. It need scarcely be remarked that the Huronian is generally held to be of much later age than the Laurentian, and to lie unconformably upon it. Of course this view may be quite correct in some other regions. If we suppose that a layer of Huronian was lifted on the shoulders of the upswelling gneiss or granite, it must have been greatly broken and fissured, so that it has been easily acted on and removed by erosion; or perhaps it was in part dissolved and lost to view in the molten rock beneath. The folds squeezed in, being compressed and rendered more solid, as well as protected by the hard gneiss on each side, have withstood the wear and tear of ages much better.

ERUPTIVE GRANITES AND GABBROS.

Later eruptions of granite and gabbro.

After the two main rocks had taken shape the era of disturbances was not yet over, for there appear to have been eruptions of granite and gabbro in several parts; and still later dykes of diabase forced their way through fissures in both Laurentian and Keewatin. These eruptive granites, which

are flesh colored or greenish and often very siliceous, break through both Laurentian and Keewatin, and are interesting as occurring in at least one case as the country rock of promising gold bearing veins. The other plutonic rock, gabbro, differs greatly from the obscure gabbros interbedded with the Keewatin schists. It is best shown around Bad Vermilion lake, where the rock varies from medium grained green varieties in which the felspar crystals have idiomorphic form, to almost white anorthosite made up chiefly of immense plagioclase crystals. A more detailed account of some of these interesting rocks will be given in the petrographical portion of this report.

Diabase dykes.

The diabase or trap dykes are the youngest rocks of the region and often form wide veins of dark rock, striking northwest and southeast. Lawson speaks of them as being commonly from 60 to 150 feet wide, and notices the remarkable difference in coarseness of grain between the center and edge. There are also very much narrower dykes, however.

Distribution of Laurentian and Huronian in the Rainy Lake Region.

Irregular distribution of Laurentian and Huronian rocks.

The various rocks which have thus far been described are very unequally distributed. By far the larger portion of the region mapped on Lawson's Rainy Lake sheet is covered with Laurentian gneiss of varying kinds. One large irregularly rounded area occupies most of the middle of the sheet and measures 45 miles from northeast to southwest, by 30 in the other direction. Its southern boundary is approximately the east and west arm of Rainy lake and 30 miles of Rainy river; Clearwater and Pipestone lakes lie to the northwest; Furlonge and Pickerel lakes to the north; Pickwick and Big Sawbill lakes and Redgut bay outline it toward the northeast. The northern part of Rainy lake with its torn and tattered outline occupies its centre. Around the gneiss an irregular band of Keewatin stretches, widening and narrowing from point to point, cutting off a small triangular portion with a slender strip of schist at the western end, and thinning out to less than a half mile in width at Redgut bay to the east. This band of Keewatin, as shown on the Rainy Lake sheet, divides off the central Laurentian area from five other important areas of the same rocks, one southwest of Rainy river in Minnesota, a second to the west, stretching from Kishkutena lake to the Lake of the Woods, a third to the north beyond Bluff and Missus lakes, a fourth to the northeast, but containing some straight or curved bands of Keewatin, and a fifth east of Little Turtle lake extending 22 or 23 miles from west to east, bounded approximately by Little Turtle river on the south and a rather narrow bow-shaped band of Keewatin on the north.

Couchiching and

A great stretch of Couchiching covers the part of the sheet south of Seine river, Rainy lake and Rainy river; and smaller bands and patches of it border the isolated body of Keewatin lying in the northeast angle of the "L" of Rainy lake.

Keewatin bands.

The Keewatin in the southern part of the sheet is mainly of the green, basic type, composed of chloritic and hornblendic schists with intercalated beds of diabase; but toward the north, the upper acid series of schists and

agglomerates, altered felsites and quartz porphyries, becomes important especially toward the north side of the wide Keewatin band enclosing the northern end of Pipestone lake, Yoke, Strawberry and Missus lakes, and the southwestern end of Manitou lake.

Outcrops of granite.

There are some minor geological features of importance,—the distribution of the granite bosses, for instance. Many of them come up through the Laurentian granitoid gneiss, a number of small ones are noted along Northwest and Shelter bays west of the north arm of Rainy lake. An oval patch more than ten miles long is placed on Bat lake a little south of Manitou. Another large mass of granite encloses Spawn inlet north of Redgut bay in the northeastern Laurentian area. Lawson indicates on his map that the foliation of the gneiss curves concentrically round these two large granite masses. Outcrops of granite occur on a smaller scale in the Keewatin also, as on the shores of Pickerel lake, at the south end of Smooth Rock lake, and between Shoal and Bad Vermilion lakes, in the last instance associated with gabbro. Doubtless many more small granite bosses than are indicated on the map will be found by more detailed examination. One which was not placed on Lawson's map was found by us to cover several square miles of country around Caribou lake, just touching the southeastern corner of Manitou lake.

Granite bosses on Bad Vermilion lake holding gold bearing veins.

The most interesting group of eruptive masses is that in the green Keewatin on the shores of Bad Vermilion lake, where three granite bosses are more or less enclosed in coarse grained gabbro or anorthosite. Lawson suggests that they represent the roots of an old volcano or group of volcanoes, perhaps one of those which gave rise to part of the volcanic ashes and lava flows now metamorphosed into the Keewatin schists, etc.; the first eruptions being of basic material (gabbro) and the later ones of more acid rock (granite).[20] The discovery of rich gold bearing veins in this eruptive area makes it of especial importance.

Eruptive dykes.

Besides these eruptive masses there are also numerous veins or dykes of eruptive rock in the region. Veins of very coarse grained granite or pegmatite appear sometimes in the Couchiching schists and also in the granitoid gneiss; while dykes of dark diabase or trap, generally with a southeast and northwest strike, are not uncommon.

Serpentine bands.

A few bands of serpentine occur in the region, as at the south end of lake Despair, and the north end of Clearwater lake, at the latter point accompanied by a small amount of chrysotile (ordinarily called asbestos). These serpentines, which no doubt result from the weathering of some basic eruptive rock, probably olivine diabase, occur only in the green Keewatin.

Character of the Ore Deposits of the Rainy Lake Region.

Bedded and fissure veins.

The more important ore deposits in the neighborhood of Rainy lake are of two kinds, bedded or segregation veins and true fissure veins, the latter being much less common than the former. Bedded veins are interstratified with the enclosing rocks, have the same strike and dip, and are generally

[20] Geol. Sur. Can, 1887, p. 57 F. Winchell and Grant appear to reverse this order, making the gabbro later than the granite. Part III, 23rd An. Rep. Geol. Sur. Minn., p. 85 and 86.

lenticular in shape. They are less likely to be contiuuous in strike and depth than true fissure veins, which cut across the stratification or foliation of the country rock. In origin however the two classes of veins are less distinct than is sometimes imagined. They are both fissures filled with minerals deposited from circulating water; the fissures probably are formed in somewhat the same way, and both generally occur where faulting has taken place.

Formation of bedded veins in schistose rocks.

Bedded veins are pre-eminently the variety found in corrugated schistose rocks, and their formation may be illustrated by the accompanying sketches. In figure 3 the schists are represented in vertical cross-section. If we imagine that by reason of earth movements, *e.g.* in the nipping in of a fold of

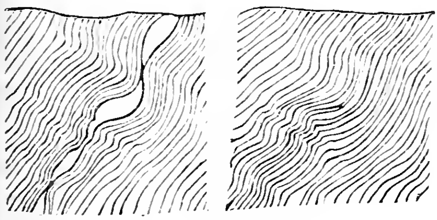

Fig. 3. Origin of bedded veins.

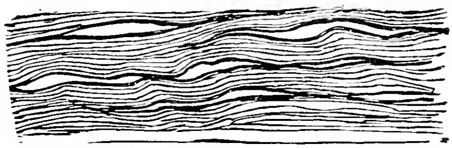

Fig. 4. Overlapping arrangements of bedded veins.

Keewatin between two bosses of granite or gneiss, there is a downward motion on one side, the schists naturally yield along the lines of weakness presented by the schistic cleavage. The folds that fitted together perfectly in the beginning do not now coincide; they touch at opposing points and leave spaces where outward curves come opposite to one another. The result is a series of cavities, opening and pinching again as they are followed downward. Such veins then are fissures formed by the faulting of corrugated schists parallel to the cleavage. Their horizontal cross section is usually very much like the vertical section in figure 3, perhaps because of some lateral motion of the rock masses; but often there are several more or less parallel veins, and not infrequently as one runs out along the strike another overlapping vein begins. Figure 4 illustrates this arrangement. Where the schist is greatly folded and contorted the veins enclosed by them share the contortions and take on quite fantastic forms, as in figure 5, which is a sketch from location K191, between Wild Potato lake and Little Turtle river. Bedded veins sometimes have quite distinct walls with slickensided surfaces, but generally are much less definite in this respect than true fissure veins.

Fig. 5. Arrangements of veins in contorted schists.

The term "segregated" frequently used for these ore deposits seems less correct than "bedded," since it implies a mode of formation by lateral secretion or segregation which is by no means proved. In fact it is probable that these veins are filled with mineral matter very much as fissure veins are.

The lack of regularity and continuity in bedded veins makes them in general less valuable as ore deposits than the more uniform fissure veins; nevertheless in most gold regions they are the usual form of vein and are mined at a profit.

Fissure veins are characteristic of massive rocks, and bedded ones of schistose rocks.

So far as my observations go, true fissure veins, crossing the strike of the country rock, are rarely found in the Keewatin schists, and when found are unimportant in size. The massive diabases interbedded with the schists sometimes contain comparatively small fissure veins filled with quartz. The Couchiching gray schists sometimes have large and well defined fissure veins, as on Goose island, and the granites likewise. It is of course clear that a bedded vein can rarely be found in a massive rock, like diabase or granite, since they seldom present even a trace of schistose structure or bedding planes between which the vein might be enclosed. True fissure veins then are characteristic of massive rocks, as bedded ones are of schistose rocks. The best examples of fissure veins with distinct walls showing slickensides, etc., in this region are to be found between Shoal and Bad Vermilion lakes.

Fahlbands.

Fahlbands, that is, bands of schist impregnated with iron pyrites and other sulphides, occur in various parts of the region, as on Nickel and Pipestone lakes. In other mining countries, such as the Kongsberg silver mining district in Norway, such fahlbands are scarcely rich enough to work as ores themselves, but the veins intersecting them are greatly enriched at these points. For this reason it may be of importance to look for veins crossing fahlbands in the Rainy Lake region.

Segregations and stockworks.

Two other varieties of ore deposits are represented in the region, segregations of ore in eruptive rocks, and stockworks. The magnetite deposits on Seine bay appear to be segregations on the margins of diabase masses, probably resembling those so well described by Vogt in Scandinavia and Dr. Adams in Canada.[21] Stockworks, or rock masses penetrated by a network of minute veins, occur on the north shore of Elbow lake, at the eastern end of the Rainy Lake country. Whether any such deposits will turn out to be of workable value is yet to be proved.

Dr. Lawson's advice to prospectors regarding the district

Dr. Lawson in his report, written several years before the discovery of gold on Rainy lake, states that "the economic value of the Rainy Lake region, as regards its mineral resources, is entirely prospective. There are no mines in the region, and extremely little search has been as yet made for mineral deposits. It is however quite probable that where such search is made the various minerals will be found which are more or less common elsewhere under the same conditions as those which obtain here. The Keewatin rocks of the Rainy Lake region are the same as those in which the gold of the Lake of the Woods occurs."[22] He further says "the Laurentian rocks of the region are, so far as they are known, perfectly destitute of metalliferous deposits, except in one instance, where, at the immediate contact of these rocks with the schists of the Couchiching at the Bear's Passage, a quartz vein occurs in which flakes of molybdenite are common . . . This remarkable barrenness of the Laurentian rocks, as contrasted with those of the upper Archæan, is a

[21] On the Igneous Origin of certain Ore Deposits, Frank Adams, Can. Min. Eng. Review, p. 8, Jan. 18, 1894.

[22] Can. Geol. Sur., 1887, p. 180 F.

fact of great interest as well as of practical importance to the prospector. On the map accompanying this report the distribution of the Keewatin rocks is mapped distinctly, so that prospectors for gold, or iron, or any other of the metalliferous ores, need not waste time examining the Laurentian country."[23]

Dr. Lawson's advice has been followed, and most prospectors have one of his maps in their outfit, and pay special attention to the strips marked green on the map. The advice given is quite natural, for in many of the world's gold regions the auriferous quartz veins are found in similar green chloritic schists; however there is a little risk of overlooking deposits which do not come in either formation, but, for instance, in the eruptives which break through them. An example is to be found in the interesting Bad Vermilion veins, which occur in eruptive granite. not always safe to follow.

In our field work we made it a point to visit all locations where any work had been done, and in general to traverse as much of the Keewatin bands as possible. Specimens for assay were taken from likely veins which we encountered, not only in the Keewatin but also in the Couchiching and Laurentian. The results will be mentioned hereafter. In reporting on the field work of the summer only those portions of the region presenting some point of interest will be referred to in detail; other portions will be described in a general way, or not referred to at all.

LITTLE AMERICAN MINE.

The first point studied was the Little American mine two miles south of the boundary, on a small island in Minnesota. It lies about a mile west of the new town of Rainy Lake city, which came into existence chiefly because of this and other discoveries of gold in the neighborhood. The first visit was on June 25th. The island consists of green Keewatin schist with a strike of about 80° west of north and a dip of 82° to 85° toward the south. Numerous small bedded veins of quartz occur—flattened, elongated rods or elongated masses with lenticular cross section. The largest vein, on which excavation was going on, appeared to be 2 or 3 feet wide, with several minor veins parallel to it. Mr. Hildreth, who was in charge of the work, says that the vein was 8 feet wide from wall to wall where he sank upon it, but included some "slate," (green chloritic schist). The work done up to this time was really quarrying, forming an irregular opening said to be about 45 feet deep, the lower part being cut off by planking at about 20 feet depth. The richest quartz is rusty and more or less vesicular near the surface, but a foot or two below one finds unweathered sulphides. The quartz is bluish gray, massive looking, contains iron and copper pyrites and a little white calcite, and is not unlike some of the quartz from the Sultana mine near Rat Portage. Mr. Hildreth proved to us by panning that both the oxidized and unweathered ore contained a considerable amount of free gold. He stated that the vein had been traced across another small island to the mainland. Location of the Little American. Character of the ore,

The work was carried on in quite a primitive way, hoisting being done with a hand windlass; and it seemed rash to erect a stamp mill, as had been done at Rainy Lake city on the eastern side of the channel, before much more

[23] Can. Geol. Sur., 1887, p. 181 F.

development work had been done. To found a "city" on the basis of this and other prospects in the vicinity seemed still more rash, but it is to be hoped that it will be justified by the future progress of the region.

and its value as shown by a mill run.

On July 19th a second visit was made especially to see the stamp mill, which had started work a few days before. It is a fairly well equipped five-stamp mill, the stamps weighing 850 lb., and dropping 7 inches. It was reported that about 30 tons of ore had been passed through the mill in 48 hours with $512 worth of gold as a result; so that the ore ran about $17 per ton of free milling gold. The concentrates were said to amount to about one-twelfth of the ore, and to have a value of $120 to $300 per ton, which equals $10 to $25 additional per ton of ore crushed, or $27.

The location of the mill on the mainland nearly a mile away from the mine was determined, as I was informed, by a bonus granted by Rainy Lake city. This necessitates the transport of the ore on scows to the mill, adding considerably to the expense of handling. The cost of the whole plant was said to be less than $21,000, including $10,000 as the price of the mine. The freight on machinery, etc., amounted to about $700.

From a Preliminary Report on the Rainy Lake Gold Region, published by Mr. H. V. Winchell and Dr. U. S. Grant, members of the staff of the Minnesota Geological Survey, the following extracts are taken, showing the history of the venture since the time of our visit:

Winchell and Grant's history of the venture.

"This mill began stamping on July 16th, 1894, and continued with some interruption until Sept. 24th of the same year, when, having used all the ore in stock and finding the cost of the operation too great, it was shut down. Shortly afterwards the operation of the mine and mill passed into other hands and plans were laid for work on a more systematic basis." After condemning the lack of business ability shown in the management of the mine and mill, the report quotes Mr. A. S. Chase, one of the directors of the Bevier Mining Company as follows: "From the best information I have the mill ran in all fifty-two days. The nearest estimate as to the quantity of ore crushed is 500 tons. We have no record of each clean up, but the actual shipments of bullion were: August 10th, $362.30; August 20th, $1,058.85; September 18th, $2,481.76; October 18th, $732.42; total $4,635.33. The cost as near as we can tell was about $7 per ton for mining and milling. With proper management it can doubtless be mined and milled for $3 per ton. We have but five stamps and of course the cost of milling would necessarily be large, but there are other reasons for the great cost of producing this bullion which can be easily overcome. The mill produced all the way from 8 to 27 ounces of bullion per day, showing very clearly that quantities of rock were crushed which, with proper sorting, would not have been used, especially with this little mill. It is certain that there was no attempt at deception, and I am fully convinced that gold in largely paying quantities exists in the Rainy Lake region."[24]

Several other claims have been taken up on the Minnesota side of the boundary, but not enough work had been done on any of them at the time of our visit to warrant a careful examination.

[24] Part III of the Twenty-third Annual Report, Geol. and Nat. Hist. Survey of Minnesota, Jan. 1895, p. 78, etc.

LOCATIONS ON THE ONTARIO SIDE.

North of the boundary many claims have been located and some of them paid for, showing the belief of their owners that they were of value. They almost all show small bedded veins in the green schists, perhaps the most promising being an islet southeast of Sand Point island, not far from the inchoate Sand Point "City" with its half dozen log houses. Owing to the unusually high water on Rainy lake, the islet was half submerged, and so far as could be seen little development work had been done. The country rock is of the usual green schists, with a band of less schistose rock which proves on microscopic examination to be a quartz biotite diorite. As vein matter we found, besides quartz, often rusty and porous and sometimes showing a speck of free gold, iron and copper pyrites in considerable amount, the latter weathering into malachite on the surface. Sand Point City.

Several claims have been surveyed farther north in the Couchiching, and on the north side of Goose island several distinct fissure veins occur, the first of any size that we had seen in the region. The strike of the brownish-gray mica schist is about east and west, while the largest quartz vein, 3 feet wide, strikes nearly north and south. The quartz is however white and barren looking, and an assay made of material taken from one of the veins showed no gold. In the Couchiching formation.

An irregular group of Laurentian exposures separates this stretch of Huronian from a parallel one to the north, running from Redgut bay westwards to the northern arm of Rainy lake. Grassy Portage and other bays give access to the center of this Keewatin belt, which includes much of the two new townships surveyed last summer, Halkirk to the east, and Watten to the west. This strip of Keewatin is unusually free from veins, and very few locations have been taken up upon it except on the shores of Nickel lake, between Rice and Grassy Portage bays, a small sheet of water not marked on the Rainy Lake sheet. These locations are upon beds of iron pyrites, apparently not nickeliferous, nor, judging from a single assay, auriferous. A barren belt of Keewatin.

A number of locations have been taken up on the north shore of Seine bay, in the green Keewatin, including many quartz veins of the bedded type, but apparently none of great importance. Some of these locations were taken up a number of years ago for iron rather than gold. The iron ores of the region will be discussed later. Locations on Seine bay.

THE SEINE RIVER DISTRICT.

The Seine River district, including several lake expansions, is the portion of the Rainy Lake region now attracting most attention. At the time of our visit no development work of any importance had been done, and there were few signs of the rush that has since covered the ground between Bad Vermilion and Shoal lake with surveyors' lines and stakes. On Grassy, Bad Vermilion and Shoal lakes.

Paddling up Seine river one passes through a reedy lake expansion, Grassy lake, where the waters of Bad Vermilion lake empty through a small river with two or three falls. Where Shoal lake begins to open out one passes several gold locations, among them on the northwest side of Shoal lake are AL76, and just to the north AL75, where the Wiegand brothers made the first important gold discoveries. When we visited them The Wiegand location

on July 10th a few men were at work opening upon a vein of quartz ten inches to a foot wide, on location AL75. The country rock, which was supposed to be gabbro as indicated on the geological map, was evidently a very siliceous variety of granite, and further examination showed that a small area of granite reaches from the shore of Shoal lake, where there is a small outcrop, northwards for an undetermined distance, and includes all the veins on the Wiegand property. This rock is rather coarse grained, greenish or flesh-colored, and greatly weathered. It differs from the granite shown on the geological map on the shores and islands of Bad Vermilion lake, being coarser in grain, more siliceous and not so white in color. Microscopic examination of slides made from our hand specimens prove the rock to be granite, or possibly, since there is a considerable amount of striated felspar, quartz diorite. The rock will be discussed more at length in the petrographical part of this report. The report of Messrs. Winchell and Grant, which has been received since our sections were examined and described, confirms the opinion just given, but mentions a somewhat schistose variety of the rock which we did not observe.[25]

in a newly discovered area of granite or quartz diorite.

Gold bearing veins of the location.

The veins on AL75, which Mr. Wiegand kindly took us round to see, are four in number, the largest about five feet in width and striking north and south. The ten-inch vein on which they were sinking strikes 6° or 8° east of north and is not far from vertical. The blasting was being carried on at a point where a cross vein striking 36° south of east joins it. The latter runs out in about 100 yards, but the four main veins striking approximately north and south are very continuous, one according to Mr. Wiegand having been followed for a mile. We found these deposits to be true fissure veins with clean walls, often lined with a gray slaty selvage, which under the microscope has the characters of sericite schist. The quartz from the blasting was rusty and "good looking," containing some free gold, pyrite and galena, the latter mineral having the reputation in the region of being a good sign of gold. In the gold bearing specimens which we obtained the metal is sometimes enclosed in solid quartz, as in some of the quartz from the Sultana mine, and so is thoroughly free milling. It is probable however that another portion of the gold is contained in the sulphides and will prove more refractory. A sample showing no free gold, assayed in the laboratory of the School of Practical Science, yielded a little over $10 per ton. In the opinion of Dr. Burwash and myself, these veins were by far the most promising seen in the region.

Since our visit many more gold-bearing veins have been discovered, and a considerable amount of development work has been done on some of them, as will be seen from the following quotation from Winchell and Grant's report.[26]

Winchell and Grant's report on the location.

"Thomas Wiegand and Alex. Lockhart discovered auriferous quartz veins on this (AL75) and adjoining locations in September, 1893. . . . The country rock immediately surrounding the veins . . . is not inaptly called 'bastard granite' by some of the explorers of the region. This rock

[25] Part III., 23rd Annual Report, Geol. Sur. Minn., p. 58.

[26] Ibid. p, 81, etc.

has often a foliation which corresponds in general with the strike of the schistose rocks which lie south of Shoal lake. . . In connection with Col. S. W. Ray of Port Arthur, Ont., Mr. Wiegand has done considerable exploring on these locations in the way of uncovering the veins and sinking test pits. Pit No. 1 was 12 feet deep at the lode, showing the vein to increase in width from about 6 inches at the surface to 20 or 24 inches at the bottom, with a vertical dip. Near the top of the ground the vein is banded pink, red and white; but the quartz is all light colored at the depth of 12 feet, and appears to be nearly equally charged with 'sulphurets' throughout. Where stringers of quartz join the vein from the walls considerable free gold is said to have been noticed."

The authors of the report go on to describe pit No. 2, 12 feet deep, on location AL94, a sample of which assayed $48 in gold; and pit No. 3 on AL75, which was 19 feet deep, on a vein from 1 foot to 3½ feet wide and growing wider as depth is attained. Two samples of this assayed $7.25 and $66.86 respectively. Of the veins in general they say: "The walls of these veins are smooth and sharply defined, being usually separated from the vein matter by a thin sheet of soft material, supposed to be the product of pressure, shearing and chemical alteration. . . . The mineral content of the different veins varies considerably. Thus vein No. 3 on Wiegand's location is more heavily charged with blende, pyrite, galena and chalcopyrite than veins No. 1 and No. 2, but is no more richly 'mineralized' than some veins seen elsewhere in this same immediate vicinity."

The Lucky Coon and Mosher properties.

They also describe "The Lucky Coon," location 655 P, north of the eastern end of Shoal lake, and east of Bad Vermilion. "The country rock here is quite similar to that at Wiegand's; but the granite is coarser and more massive, and has pink felspar crystals developed in it at a short distance from the veins." This property is owned by Americans. "The vein has a width of about 6 feet and has good walls. It is banded or 'crustified' and contains considerable pyrite, chalcopyrite, blende and a dark mineral resembling argentite. This vein has been traced for more than half a mile by surface outcroppings." Ore from this and another vein on the property assayed $2 and $43 per ton. The Mosher properties, AL110, AL111 and AL112, are referred to as showing free gold. The veins are in the same rock as the two previous properties, and one of them is 6 feet wide.

Since the writing of the report from which extracts have been made a post office has been established on Shoal lake, a stamp mill has been brought in for the Hillyer or Lucky Coon mine, and the sinking of shafts has been begun on various properties; so that probably another summer will show a lively mining camp in full blast. Of course none of the work done hitherto can be looked on as more than prospecting, and until much more development has taken place the real value of this very promising district will not be settled.

Locations on Wild Potato lake.

About five miles above Shoal lake the Seine opens out into Wild Potato lake, the shores of which are largely occupied by an Indian reserve, 23A. Two miles north of the western end of the reserve, and just south of Little Turtle river, are two locations from which rich gold specimens are said to

have come, K190 and K191. The country rock is very fine grained and schistose, and of a light purplish to greenish-gray color. A microscopic examination shows that it is a schistose felsite, so that though colored green on the geological map it probably belongs rather to the acid upper series of the Keewatin than to the usual basic variety. The veins, which are very numerous but not very large, strike parallel to the schists, about north 75° east, and are of the bedded variety.[27] The opening, made by blasting, is only 3 feet deep and does not disclose any one distinct vein, but rather a network of veins. The quartz looks rich, and where unweathered contains pyrite, chalcopyrite, with a little malachite and galena. Quartz from this vein which I have seen crushed and panned showed many colors of gold; but too litt'e work has been done to warrant any definite statement as to the value of the property.

A series of locations has been taken up between Seine bay and the north end of Bad Vermilion lake, in the Keewatin schist, and a band of gabbro that runs along the northwest shore of the lake. Some of these were visited, but nothing of special interest was observed.

ON THE UPPER SEINE WATERS.

Between Seine bay and Bad Vermilion lake.

Several gold discoveries have been made farther east, above Sturgeon Falls, the head of steamboat navigation on Seine river. It was intended to visit these in September by way of Lac des Milles Lacs and the Atik-okan river, but low water on the river and serious forest fires, which made the portages almost impassable, prevented the carrying out of this plan. Handsome specimens of native gold come from Harold lake, where the Wiley Brothers of Port Arthur have locations. An assay of a specimen from that locality given by them showed $165 per ton. Gold has also been found near the Atik-okan iron deposits, at Osinawe lake, and at Partridge lake east of Lac des Milles Lacs. The last deposit is described as having been found in 1872 by Mr. Archibald McKellar. Free gold has been obtained here, and specimens of ore which assayed from 1 to 1½ ounces of gold per ton, as reported in The Mineral Resources of Ontario.[28] This location was visited by the present writer on August 31st. A small island in the lake, where some blasting has been done, consists of greenish-gray graywacke and some chloritic schist, no doubt Keewatin in age. In this were bedded quartz veins, sometimes 3 feet wide, striking about north 30° east, and with nearly vertical dip. The quartz is white, sometimes saccharine in look and sometimes rusty, and contains few sulphides. On the adjoining mainland the same vein, or a parallel one, can be traced for 80 or 100 feet, with a width of from 2 to 4 feet. The quartz is white, with few sulphides, like that of the island, but the country rock is a rather coarse-grained, greenish rock, which under the microscope appears to be quartz diorite, or possibly a granite rich in plagioclase felspar. It reminds one

Locations on Harold, Osinawe and Partridge lakes.

[27] See illustration, p. 51, which is from K191.

[28] Report of the Royal Commission on the Mineral Resources of Ontario, Toronto, 1890, p. 26.

slightly of some of the Shoal lake granite, but is probably interbedded with the Keewatin schists. The work done on Partridge lake is not sufficient to give any certain idea of the value of the deposits.

From what has just been written it will be seen that the Keewatin extends almost due east for about 100 miles beyond the Little American mine, along Rainy lake and the valley of the Seine and its tributaries; and that gold bearing veins occur in it from point to point along almost the whole distance.

Extent of the Keewatin schists.

Thus far only those veins which occur in the Keewatin or the associated eruptives have been referred to. It remains to mention one or two veins found in the Laurentian. The first, at the narrows three or four miles east of Redgut village on the Indian reservation, contained "good looking" quartz in dark syenitic gneiss; a second is an irregular mass of quartz in gneiss near the village, probably a bedded vein. The quartz contains galena, pyrite, etc., and looks promising. Neither gave any gold when assayed. A third point where veins are observed is on the east side of the Bear's passage. Here there are many irregular veins of quartz which is reddened with iron oxides. Pyrite also occurs in considerable amount, and the vein matter looks very promising in spite of its occurring in Laurentian granite or perhaps granitoid gneiss, but here again the results of an assay were negative.

Veins in the Laurentian, near Redgut village and at Bear's passage.

GENERAL CHARACTER OF THE VEINS AND ORES.

There was an opinion commonly expressed last summer among prospectors that the gold deposits of the Rainy Lake and Seine district were to be found along certain definite lines or horizons, and that one could find a certain continuity in the gold bearing series of veins. This seems to be true however in a very general way only. The southern portion of the green Keewatin schists, stretching as a long band from the Little American eastward up the Seine and Atik-okan, seems to be more auriferous than other parts of the Keewatin of the Rainy Lake district; but when one comes down to particulars one finds that up to the present no one auriferous horizon can be traced for any great distance. The Little American series of bedded veins on the southern side of the southern band of Keewatin cannot be followed very far. The Little Canada veins belong to the north side of the same Keewatin band. The rich Shoal lake veins run in a contrary direction and are of a totally different kind, since here eruptive granite and gabbro interrupt the continuity of the Keewatin. Farther east the gold bearing veins of K190 and K191, just south of Little Turtle river, are on the north side of the Keewatin band, and in a felsitic rock quite different from the green schists where the gold occurs toward the west. The Partridge lake gold deposits, while in an extension of the same general direction, occur in still another variety of Keewatin, greenish-gray, graywacke and interbedded quartz diorite.

Gold bearing veins in the Keewatin schists,

in eruptive granite,

and in felsitic rock.

Twenty assays were made in the Laboratory of the School of Practical Science of ores from more or less promising looking veins in various country rocks of the Rainy Lake and Seine River districts. These were chosen so as to cover the ground as generally as possible. From bedded veins in the Keewatin 12 assays were made; 8 gave no result and 4 ran from a trace to 8

Assays of ores from the district.

ounces of gold per ton. Care was taken to select specimens showing no visible gold. If specimens showing free gold were counted as favorable assays, the results would be 6 containing gold out of 14 altogether. Assays were made of ores from three veins in the Couchiching, all with negative results; and the same is true of three specimens from veins in Laurentian rocks. Out of two assays of ore from fissure veins in the eruptive granite at Shoal lake, one gave $10 in gold and another nothing. Specimens from one of these veins containing visible nuggets would of course have run very high in gold. The results of these assays are given, not with the idea of settling the value of the different parts of the region, but merely to give a general basis for comparison of the different formations as ore carriers. It is of course well understood that a single fire assay is a most unreliable test of a gold bearing vein. Unless a number are made and averaged, and unless the ore is very carefully sampled, the results of fire assays for gold may be very misleading. The only satisfactory test is a mill run of fairly selected ore.

Examination of the Northern Part of the Rainy Lake Region.

The Pipestone and Manitou country.

After examining the portion of Keewatin running east and west along the eastern arm of Rainy lake and the Seine and its tributaries, it was decided to go north and explore the Pipestone and Manitou country, then attracting some attention. Apparently little prospecting has been done in the irregular and rather inaccessible strip of Keewatin reaching from Redgut bay northwest to lake Manitou; and the long stretch mapped as Keewatin along Rainy river is mostly covered with thick alluvial deposits, so as to be out of reach. The Pipestone and Manitou are however easily reached and lie in the heart of a wide band of Keewatin.

Lake Despair.

Instead of taking the usual Manitou route directly north from Rainy lake we turned off to the west into Northwest bay, and then over lake Hope into lake Despair. The western end of the latter body of water cuts across a narrow strip of Keewatin schists, in which some quartz veins were observed, but not very promising in appearance. A number of white veins of granite (or gneiss) seen from a little distance were deceptively like quartz veins. No blazes or other marks of prospectors were seen.

Clearwater lake.

Clearwater lake lies mostly within a wider band of Keewatin, and was more carefully studied. Here and there strips of the green hornblende schists of the Keewatin were observed, but acid pale gray felsite schists are more common, and some agglomerates, or rocks formed of masses of coarse quartz porphyry tailing out in fine grained greenish schist, are found. An assay of rather barren looking quartz from a vein in these agglomerates yielded nothing. The acid eruptives of this lake seem to contain few veins, and those of an unpromising kind. Near the upper end of the lake some

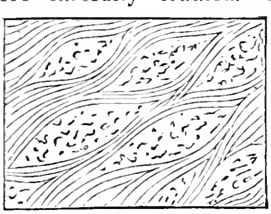

Fig. 6. Agglomerate. Clearwater lake.

true fissure veins from 5 inches to 2 feet wide are found, but their contents seem almost free from metallic minerals. Panorama and Burnt lakes to the west of Clearwater are in the green Keewatin, but their shores as far as observed present only unimportant veins of quartz. First Quill, Narrow and Link lakes, which lie between Clearwater and Pipestone lakes, are enclosed in Keewatin rocks, both schistose and massive, containing, especially when schistose, bedded veins and stringers of rather white quartz. An assay of material from First Quill lake gave no gold.

Pipestone lake, with the exception of two bays on the western side near the lower end, where a small area of granite crops out, lies wholly within the Keewatin. It is a comparatively large lake full of intricate channels, such as "The Gates Ajar Narrows," varying in their directions to correspond with the varying strike of the schists. The lower end, running about northeast and southwest, is enclosed in green schists; the upper, almost at right angles to it, is bordered by altered quartz porphyries and soft glossy gray schists and slates. A number of claims have been staked on the lower part of the Pipestone, though none had been surveyed, so far as we observed. A considerable number of quartz veins show themselves in the softer green schists, a few of them fissure veins, but the harder schists and massive diabases contain very few. No bodies of quartz of any size were observed near the granite boss to the west, which is probably not eruptive; Lawson colors it as Laurentian. It differs very much from the Shoal lake granite, being much less siliceous. Along the shores of a deep bay opening toward the west, about 6 miles up the lake, a number of small and a few large quartz veins are seen, but the quartz is ominously white. Higher up the lake several claims have been staked on islands, generally including more or less promising looking quartz veins; but in one or two cases the attraction seemed to be thick beds of pyritous schists which become brown and rotten when weathered. At a point on James bay there are large quantities of such soft rusty schists heavily charged with pyrites, which may properly be called a fahlband. Fresher portions from underneath the gossan are fine grained, pale green, and filled with small striated cubes of pyrite. An assay of some of this material gave a trace of gold. A sample of coarser grained green schist with much pyrites and some stringers of quartz yielded about $2 of gold. As these mineralized beds of schist occur in considerable amounts toward the middle of the lake it is possible they might pay to work for themselves, and if quartz veins should be found in these fahlbands they will probably turn out richer than elsewhere.

Pipestone lake.

Mineralized beds of schist.

A small lake about $2\frac{1}{2}$ miles long, unmarked on the map, was found just west of the central part of Pipestone, and named lake Helena. It lies also in the Keewatin, and its shores present a few quartz veins much like those of the larger lake. The nearly east and west upper part of Pipestone lake and Schist lake, both in the felsite schists of the upper Keewatin, were barren so far as we observed. A considerable deposit of pyrrhotite at Stonedam portage, and the pipestone or steatite from which the lake gets its name, will be referred to later. On the whole the central portion of the lake appeared more promising than anything we had seen since leaving the Seine.

Lake Helena.

Yoke, Sucker and Furlonge lakes.

Yoke lake to the northeast of Pipestone lies in pale green hard schist, mapped by Lawson among the acid series, and seems almost devoid of veins of any description. Sucker lake showed no signs of ore deposits, nor did Furlonge lake, which was reached by means of a hopelessly shallow weed-filled creek. We were surprised to find the large peninsula to the south of that lake made up of coarse grained granitoid gneiss and fine grained red granite, instead of green Keewatin schist as indicated on the map ; however the shores of the lake present very few outcrops, and those of a kind so low and vegetation-covered as to be easily passed over.

From Strawberry to Manitou lake.

Strawberry lake and the two small lakes between it and Missus lake to the east are enclosed mainly by the more siliceous upper Keewatin, and displayed no veins that looked promising. Instead of going east to lake Manitou via Missus, Harris, Sairy Gamp and other lakes redolent of Dickens, we struck south from the second lake east of Strawberry, made a long portage to Cross lake not shown on the maps, and then by another rather long portage reached the lower end of lake Manitou. Cross lake, which is about three miles long, is enclosed chiefly with green Keewatin rocks holding a few veins of white quartz.

A great fault.

Pickerel lake, which is just south of the lower end of Manitou, from which it is separated only by a short rapid down which canoes can run, turned out to be very barren of veins, as however might have been expected from the fact that its shores consist mainly of soft gray slates and felsites, except where the rocks are interrupted by two bosses of granite. At the outlet to this lake through Cedar narrows there is a profound fault, which Lawson estimates at 2,000 feet in a horizontal direction.[29] It is a surprise to find so little fissuring where there must have been so great a disturbance, but no quartz veins were observed in the vicinity.

MANITOU LAKE.

General description of the lake.

Manitou lake is, after Rainy lake, the largest body of water in the region, measuring about 30 miles in length by 6 in greatest breadth, and running northeast and southwest. It is one of the most beautiful lakes of the system, having clear water and great variety of shore ; and its contour is so complicated by reason of deep bays and channels that its coast-line measures more than 160 miles, without taking smaller indentations into account. Two comparatively large bodies of water are connected by a narrow river-like portion, and from the southern end of the southwestern expansion a narrow arm stretches eight or ten miles further southwest to Pickerel rapids, by which its waters are discharged into Pickerel lake and thus into Rainy lake. For convenience we shall refer to the large expansion just above the southwestern arm as the Lower Manitou, and to the expansion at the upper end as the Upper Manitou. The whole of the lake lies within a wide band of Keewatin, with the exception of a few bays on the northeast side of Lower Manitou. Unfortunately the sheet of the geological map covering the Manitou is not yet published, and no really satisfactory topographical map

29 Report on Rainy Lake Region, p. 33 F.

exists, though tracings from the map in the Crown Lands Department of Ontario cover the portions that have been surveyed.

The southwest end of Lower Manitou and some adjoining lakes will be taken up first. A claim has been staked just east of Pickerel rapids on bedded quartz veins, in rock indicated on Lawson's map as soft glossy gray schists and slates. The material from the veins is "good looking," consisting of rusty quartz, with a considerable amount of iron pyrites and galena, the latter mineral being considered a tolerably sure indication of the presence of free gold. An assay of some of this quartz gave less than two dollars' worth of gold per ton. So far as was observed the body of ore is not large. This is the only instance that turned up of gold-bearing quartz in the "soft gray schists and slates." At this point the direction of the lake as well as the strike of the schists is about east and west; but about four miles east of Pickerel rapids the schists are of the green variety and strike northeast and southwest, while the lake bends toward the same direction, northeast. A tangle of long narrow bays and lakes lies just to the southeast, mainly in the green Keewatin, but their shores present few quartz veins, and none were seen that require particular notice. The largest of the tributary lakes, Dog Fly lake, lies between the green schists and eruptives and very striking schist conglomerates, in which both enclosed masses and the ground mass are of green or gray schist. But one small white quartz vein was observed on its shores.

Southwest end of Lower Manitou.

Dog Fly lake.

Caribou lake, just north of Dog Fly lake, is represented on the geological map as having the same relations to the Keewatin, but we found between it and Manitou a considerable boss of granite, probably occupying two or three square miles, and just showing on the shore of a small bay east of Manitou lake. It is probable that this was forest covered ten years ago, when the survey was made, so that the rounded, reddish hills could not be seen; but at present one can recognize them as granite from a distance. The rock is coarse grained, and at its edges seems to have fused with the green Keewatin, forming a somewhat darker colored schistose rock containing much hornblende as well as orthoclase, but very little quartz; according to its composition, syenite. This granite burst through the schist, since it has carried off fragments of it, and hence is of later age than the Keewatin. No quartz veins were seen in the granite, which is less quartzose than that of Shoal lake.

Caribou lake.

A granite area.

Four or five miles northeast of this granite boss lake Manitou widens greatly, and has stretches of open water several miles long, though the upper end of Lower Manitou is filled with large and small islands. There are several mining locations on this portion of the lake, which is beyond the limits of the Rainy Lake sheet of the geological survey. The southeastern shore is wholly of green schist, mixed with ash beds or greywackes and conglomerates of the Keewatin. It presents no special points of interest, except some beds of schist, with quartz very heavily charged with pyrite. The main bed is about five feet thick, but assay showed no gold in the pyrite from this fahlband. On the southwest end of this part of the lake there are several bays two or three miles long. The shores of the most southerly one are of

Lower Manitou.

greywackes, with some green schist, sometimes containing white crystals of plagioclase an inch in diameter. Several large irregular masses of white quartz were observed here, and one or two veins of good looking quartz, in one case containing copper pyrites and a little malachite. An assay of the latter gave a trace of gold. In the two long bays to the north of this, one finds hard gray green schists which have quite a remarkable cleavage into board-like slabs. When weathered and lying tumbled together they sometimes look like a heap of cordwood or logs. The most northerly of the three deep bays projecting from the southwest end of this expansion of the Manitou ends in porphyritic syenite gneiss, the *augengneiss* of the Germans, a characteristically Laurentian rock. The dip of the schists becomes very low, not more than 30°, just before one reaches the gneiss. Turning to the upper end of the Lower Manitou, the large islands filling this part of the lake consist of greywackes and conglomerates, with some green schists, all Keewatin. They contain some bedded quartz veins and some large, irregular masses of quartz, one specially promising. A bed of whitish felsite has been staked as a claim, but it is very doubtful if it contains gold. It may have been taken for a quartz vein.

Syenite.

At the northwest corner of Lower Manitou the shores are formed once more of syenite, so that it is evident the Laurentian extends from southwest to northeast a short distance from the shore. A little east of this at a point on the north end of Lower Manitou two locations have been surveyed, 166P and 167P. The rock at 166P consists of dark hornblende schist, green hornblende chlorite schist and flesh-colored felsite schist, all interbedded. Large quartz veins, one six feet wide, occur at this point, containing very rusty ore with a considerable amount of pyrite. The specimen assayed however contained no gold, though the quartz looks as though it should. A little to the east of this several locations have been surveyed on moderately large quartz veins of a more or less promising appearance. A location has been taken also just as one turns to the northeast out of Lower Manitou on a true fissure vein five or six feet wide in places, and traceable at least 100 yards. This is in diorite schist like that found at 166P. There are several other large veins near by, but the quartz looks rather white. On the way up the river-like stretch leading to Upper Manitou the rocks are chiefly of the characteristic green Keewatin, containing at a few points bedded quartz veins very much like those on Rainy lake; but some large masses of hard, tough greywacke and schist conglomerate are found also. Just before the entrance to the Upper Manitou a dyke of yellow felsite schist crosses the green hornblende schists, so that the felsite is, in this case at least, a true eruptive rock of later age than the green schist. This case will be further described in the petrographical part of the report.

Mineral locations.

An eruptive felsite dyke.

The majority of the locations on the Manitou are on its upper part, and as some of them are of great interest this part of the lake will be described with some detail. This sheet of water is nearly ten miles from end to end, and has the usual northeast and southwest trend. It should in reality have a name of its own as a separate lake, for a very narrow though short channel

Upper Manitou.

with a stiff current connects it with the rest of the straggling body of water called lake Manitou. The entrance to the Upper Manitou is quite masked with points and islands and might easily be missed altogether, and on several of the older maps this upper expansion is not indicated at all. A large part of Upper Manitou is filled with islands, and there are no long stretches of open water. A number of the islands have been surveyed as gold locations, on one of them, 150P, containing a considerable number of bedded veins and irregular masses of quartz, a little blasting has been done. One of the veins is five or six feet wide and good looking. The quartz is very rusty, contains iron and copper pyrites, and is interbedded with a country rock of greywacke and diorite. If the quartz of this island turns out to be even moderately auriferous the ease of mining and the large quantities exposed would make it very profitable to work. However, the result of two assays from this location was negative. A shaft about 25 feet deep has been sunk in the middle of the island. On the mainland adjacent there is a vein of mixed quartz and felsite eight or ten feet in width, greywacke being the country rock.

Gold locations in and near the lake. 150P.

Location 131P, comprising a point, almost an island, at the southeast end of Upper Manitou, was one of the earliest locations taken up by the well-known prospector LaCourse. The weathered surface of the quartz was exceedingly rich in gold, and very handsome specimens are shown, reputed to have come from it. A small amount of development work has been done on the lake shore, the rock having been blasted out to a depth of twelve or fifteen feet, but at present there is no indication of a vein, either bedded or fissure, in the hole blasted out. The quartz from the surface is very rusty and cellular; but lower down it is white and glassy, with many cubes of pyrite and portions of other sulphides. An assay of this ore gave $186 of gold per ton, by far the best result in the Manitou country. The adjoining rock contains some green schist, but consists chiefly of a fine grained gray mica schist or gneiss, which has not at all the look of a Keewatin rock; on the contrary, it appears something like Couchiching. As however this rock is found only at this southwest corner of the lake, and all the rest of the shore is distinctly Keewatin, it may perhaps be looked on as a Keewatin rock considerably modified in the neighborhood of the Laurentian; for the latter formation must lie only a short distance to the west, judging by the strike of the schists and the outcrops found on the north end of Lower Manitou, four or five miles to the southwest. I am informed by Mr. Rochon that there is another vein several feet wide on the other side of 131P, on which no work has been done, but which is much more promising than the one described. Just north of this location a vein of white quartz four feet wide occurs in similar mica schist or gneiss; but here and there green Keewatin is interbedded with the gray schist.

131P.

Farther to the northwest, on the shore of the lake, diorite and hornblende schists and massive green diabase appear, evidently rocks of Keewatin age; and here and there in them one finds bedded quartz veins as well as a few fissure veins, on which no claims have been staked. The Keewatin schists are of the hard hornblendic kind usually found near the contact with the

Laurentian. Still farther northeast bands of felsite are intermixed with the green Keewatin and a few small, almost horizontal, veins of quartz occur.

At the time of our visit, the middle of August, there was only one location on which work was being done, 133P, near the northeast end of Upper

133P. Manitou and a mile north of the entrance. Here Mr. Rochon, of the firm Lillin and Rochon from Keewatin, had a small party engaged in the development of a bedded vein of quartz charged with sulphides. The thickness of pure quartz was about $1\frac{1}{2}$ feet, but the width of schist intermixed with quartz was much greater. A half-pound of the ore crushed in a mortar and panned afforded a number of colors of gold, and a nice specimen of free gold was taken out during our visit. They had gone down to a depth of about 12 feet, and the country rock, which is variable, consisted of a hard, fine grained, pale greenish felsite schist. Not far off the ordinary green Keewatin schist was found. Some other veins of rather rich looking quartz were pointed out by Mr. Rochon, who stated his intention of testing them later. The quartz from this opening differs a good deal from that found elsewhere in the region. It is white and mixed with flesh colored felspar with yellowish chlorite or serpentine, and cubes of pyrite sometimes a third of an inch through. At times the serpentine shows the polishing and striation of slicken-

155P. sides, indicating faulting when the vein fissure was opened. The location 155P, including the short rapid forming the mouth of Upper Manitou, belongs also to Lillin and Rochon, and contains quartz veins similar to that now being developed. Near the channel some good examples of brecciated vein matter were found. A large island southwest of 133P consists of schist conglomerate, ordinary green schist and felsite schist, with some very large masses of quartz, chiefly white and barren looking.

Promise of the Manitou region.

Up to the present Manitou lake has yielded only specimens, some of them exceedingly fine however. There is no mine and no stamp mill on its shores and the deepest exploration at the time of our examination in the middle of August did not go down more than 25 feet. Ten assays in all were made of ore from various claims and locations on the lake, with the result that four contained gold running from a trace to \$186 per ton. Some specimens from deposits having a very favorable appearance gave no gold on assay, though this of course may have been an accident, and the locations showing the largest bodies of ore made the poorest showing in this respect. By far the richest of all, LaCourse's, seems to lie just at the contact of Keewatin and Laurentian. One gold bearing specimen was obtained from the southwest end of the lake, another from the lower expansion, and the other two from the Upper Manitou; the latter portion of the lake affording by far the richest specimens and having on its shores and islands perhaps nine-tenths of the locations which have been taken up.

Means of access to the Manitou lakes.

What the ultimate value of this portion of the region will be can only be guessed at, until very much more development work has been done; and that can hardly be expected until the means of communication are greatly improved. At present the only means of access is the canoe in summer and a dog train in winter. Two canoe routes are available, one from Rainy lake

on the south, requiring a long day's paddle; and a somewhat shorter one from the Canadian Pacific at Wabigoon. In distance the latter route is much the shorter, the upper end of Manitou lake being only 20 miles in a straight line from Wabigoon station; but in time there is less difference, since there are six portages, some of them long, and one of them troublesome from muskegs. At the time we passed through the water was low, lengthening one of the portages seriously; and the wild rice had grown so tall and dense at the narrows near the upper end of Little Wabigoon that we lost much time in forcing our canoe through it. That portion of the lake was in fact a great harvest field loaded with grain, and having a few inches of water at the foot of the stalks. The Ontario Government intends, I believe, to cut a wagon road from the northeast end of Manitou to a small lake six or seven miles to the north, the head of navigation on the Wabigoon chain of lakes. It is expected that small stern wheel steamers will be able to make their way up to this point. At the time we followed the route this hardly seemed possible, so crooked and shallow was the river, and so dense the growth of rice and other water plants at the Little Wabigoon narrows; however, in high water no doubt the water ways are much more passable.

LAKE WABIGOON.

The shores of the small chain of lakes between Manitou and Wabigoon consist, as far as observed, of green and grayish green Keewatin; and the same appears to be true of the western and southern shores of the two portions of Wabigoon lake. The strike of the schists on the southeastern body of water was observed to be about north and south, and the dip nearly vertical at the Indian village; but on the south shore of the larger east and west stretch of the lake the strike is approximately east and west. It is evident that the band of Keewatin reaching up toward the northeast from Pickerel lake, along the line of Manitou lake, turns north at Little Wabigoon and sweeps to the west along the shore of the greater Wabigoon, on its way to complete another mesh of Huronian, enclosing a large area of Laurentian.

From Manitou to Wabigoon.

Course of the Keewatin band.

There is one interesting location on lake Wabigoon, Oliver Daunais' Wabigoon mine, about four miles southeast of Barclay station on the Canadian Pacific Railway. A shaft 65 feet deep has been sunk near a small lake south of the larger one, and a small house built. At the time of my visit all was deserted and the shaft half full of water. Several openings had been made at other points near the shaft. The ore is white quartz, often enclosing much gray or brownish rock matter as a breccia, and also copper and iron pyrites. Grayish schist from the walls is often more or less filled with cubes of iron pyrites. The veins appear to be of the usual irregular bedded type, and the country rock is either schistose or apparently massive. An assay of the ore gave about $3 per ton in gold.

Wabigoon mine location.

Some Ore Deposits in the Lake of the Woods Region.

Relations of ore bodies to enclosing country rock.

For the sake of comparison several mines and prospects near Rat Portage and Rossland were visited, special attention being paid to the country rocks enclosing gold bearing veins. In regard to the mines themselves nothing need be said, since a good account of them is given by Mr. Blue, Director of the Bureau, in his Report for 1893. Several of the more important mines were described ten years ago by Mr. Coste,[30] but of course many new deposits have been discovered since. Mr. Blue collected a large number of specimens of both ores and country rock, and these were afterwards submitted to the present writer for determination; but the study of an isolated piece of rock is so much less satisfactory than a study of the same in connection with its stratigraphical relations that it seemed useful to go over a portion of the ground again. In the present report the relations of the ore bodies to the enclosing country rock will be briefly described, other points being neglected.

Sultana mine.

One naturally begins with the Sultana mine on the island of the same name, up to the present almost the only steady producer of gold in the province. Here we find the ore to be quartzite, enclosed as bedded veins with a nearly vertical dip in chloritic and hornblendic schist of Keewatin age. The general appearance of both quartz and schist reminds one of those of the Little America and other ore deposits on Rainy lake, though none of the latter show quite the same very fine grained quartzite structure of the quartz. The Sultana is close to the edge of the Laurentian, which is here a gray, coarse-grained, granitoid gneiss, showing little foliation, very like some gneisses of the Rainy lake region.

Ophir Jack mine.

A short distance to the south, on the same island, is the Ophir Jack mine, wholly enclosed in gneiss, and apparently a true fissure vein. The Ophir Jack, which is really only a prospect hole, never having been worked in a business-like way, has produced many exceedingly fine specimens of nuggets in quartz, and the ore is quite different in aspect from that of the neighboring Sultana, since the quartz is white and more massive. With the vein quartz on the dump portions of dark chloritic and micaceous schists are found, quite different in appearance from the country rock of the Sultana mine, and unlike any rock seen in the vicinity.

Gold Hill and Black Jack mines.

A few miles southeast of the Sultana a number of mines have been more or less opened up; of these the Gold Hill and Black Jack were examined. At the former mine there is a true fissure vein of white quartz, with some sulphides in a gray green, massive looking country rock, which under the microscope appears to consist mainly of hornblende, replacing a weathered augite, so that it is probably a much decayed diabase, one of the igneous beds of the Keewatin. Around the Black Jack mine one finds fine grained, massive diabase and green chloritic and hornblendic schist, both quite like Keewatin rocks from Rainy lake. A band of diorite porphyrite, speckled with white porphyritic crystals of striated felspar, which occurs near by, may perhaps be compared with the porphyritic green schists sometimes found near the Laurentian of Rainy lake.

[30] Geol. Sur., Can, Report of Progress, 1882-83-84, Part K.

Several interesting mining locations were visited near Rossland. a station on the Canadian Pacific just east of Rat Portage. Lawson's map of the Lake of the Woods includes this part of the country in the Laurentian, describing the rocks as merging into ordinary gneisses, though they are "coarsely crystalline basic rocks, composed largely of triclinic felspar, hornblende and biotite, with a little bluish quartz."[31] The region turned out to be much more varied than had been expected, for typical Laurentian rocks are intermingled with others having the character of the Keewatin. The Rossland region.

The Bad mine, scarcely more than a prospect hole, is specially interesting geologically. It is sunk upon a bedded vein striking about southeast and northwest and dipping 50° or 60° to the southwest, containing white or pink quartz, with iron and copper pyrites, galena and much free gold in small scales and nuggets. It took but a few minutes to gather from the dump a number of specimens showing the yellow metal. Below the vein one finds a coarse grained biotite syenite gneiss, gray in color, and just above it a rather fine-grained red granite or granitoid gneiss, forming a bed 10 or 15 feet in thickness. Above the red layer there is the usual coarse grained gray gneiss of the region. Both rocks have a thoroughly Laurentian appearance, and the bedded gold bearing vein seems to be a contact deposit. The gold appears here entirely dissociated from the Keewatin or Huronian, the only marked instance of the kind that I have observed in the region. It is possible however that the red granite is a dyke of later age, and corresponds to the siliceous granite near Shoal lake, which it resembles in being very siliceous and in containing an unusual amount of plagioclase. Under the microscope the rock shows evident signs of having undergone crushing. Bad mine.

Near by, on location D98, the writer saw gold obtained by panning material taken from a vein of felsite in black hornblende schist, no doubt both belonging to the Keewatin. Some sulphides and glassy black quartz were associated with the felsite, and probably carried the gold; but there was no distinct quartz vein. Neighboring locations are the Norway mine in hard green schist near granitoid gneiss, and the Treasure mine, where gold bearing quartz veins are connected with felsite bands in gneiss, probably belonging to the Laurentian. Some distance to the north, near the shore of Island lake, is the El Diver mine, where small quartz veins occur in green hornblende schist and also in the adjacent syenitic gneiss. D98, Norway, Treasure and El Diver.

Almost all the gold locations visited by the writer in the Lake of the Woods region appear to lie along the disturbed margin of the Laurentian and Keewatin; gold bearing veins, both bedded and true fissures, occurring within the Laurentian gneisses as well as the Keewatin schists, as though they partook more or less of the nature of contact deposits. If the gneiss is really a species of plutonic rock which has heaved up, fissured and folded the already solidified Keewatin, the occurrence of veins along and near the contact seems very natural, for those convulsions must have opened up many channels for the flow of water, highly heated by the molten or half-molten rock beneath, the very conditions favorable to the deposit of ores. In this respect the Peculiarities of Lake of the Woods region.

[31] Note on maps published with the report on the geology of the Lake of the Woods region, 1885.

Lake of the Woods gold region seems to differ greatly from that of Rainy lake, where scarcely any important gold bearing veins have been found near the edge of the Laurentian, and none whatever within the Laurentian The important Shoal lake veins occur near the contact of granite and Keewatin, but the granite seems to have no connection with the Laurentian.

General Conclusions.

Characteristics of gold bearing rocks in the Rainy Lake region.

In summing up the results of the summer's work, one may say that gold has been proved to exist at many points in the region explored, but always in rocks of Huronian or Keewatin age, or in eruptives bursting through them, never in undoubted Laurentian; a point of difference from the Lake of the Woods region, where the association of gold bearing veins with the Laurentian gneisses is not uncommon. The gray mica schists and gneisses of the Couchiching, underlying the Keewatin so extensively in the southern part of the region, have not as yet been shown to contain gold. The suggestion of Lawson, then, regarding the probably auriferous character of the Keewatin is borne out by the results of prospectors' work up to the present. The rocks of the Keewatin vary greatly in character, some being soft or hard green schists with interbedded massive greenstones, others greenish gray fragmental rocks, and still others yellowish or reddish siliceous rocks, felsite schists, derived from quartz porphyries. Gold is found most frequently in the softer green schists, but also at times in the fragmentals and the felsite schists. The massive greenstones seem rarely if at all auriferous, and the same appears to be true of the coarser conglomerates and agglomerates. In the Rainy Lake—Seine region proper—the Keewatin schists do not appear to be more auriferous near the contact of the Laurentian gneisses than elsewhere; but the richest gold bearing quartz of the Upper Manitou occurs at the greatly altered margin of the Keewatin. The eruptive masses of granite in the region have been proved to be auriferous in only one case, near Shoal lake, and here the adjoining eruptive mass of gabbro, or rather anorthosite, may have been the determining cause; though, so far as the writer is aware, no gold bearing veins have been found in the anorthosite itself. Winchell and Grant say that "perhaps the most favorable feature of the veins of this particular portion of the Rainy Lake district is their intimate relation with the areas of the eruptive rock called 'gabbro' on the north and of greenstone on the south. . . . It is not clearly proven that the veins date from the advent of the gabbro; but the fact that the gabbro seems to be later than the peculiar granite area lying between Shoal and Bad Vermilion lakes, and the further fact that the veins are quite different in strike from the other veins around Rainy lake, and appear to radiate from the gabbro area as a center, is strongly indicative that the formation of the fissures was due to the irruption of the gabbro.'[32] Lawson holds however that the gabbro is earlier in date than the granite.[33] Which authority is correct

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[32]Part III. 23rd An. Rep. Minn. Geol. Sur p. 85 and 86.

[33]Rep. on Rainy Lake Region, An. Rep. Can. Geol. Sur.. 1887, p. 57F.

the writer cannot attempt to decide, since the region at the time of his visit was quite undeveloped and was not studied with reference to the time relationships of the eruptive rocks.

The gold bearing veins are generally of the bedded or segregated variety in the Keewatin schists, though true fissure veins are not absent. In the granite the gold is found in true fissure veins only.

Minerals associated with gold.

The minerals associated with the Rainy Lake gold are those usually found in other gold regions, and the country rock enclosing the veins is like that of many important goldfields. The gold of the Black Hills in South Dakota occurs in fahlbands and in bedded quartz veins in slates and schists of Archaean age,[34] that of the Southern States occurs in bedded quartz veins in metamorphic slates, talcose schists, etc., of late Archæan or early Palæozoic age, with numerous associated diabase dykes;[35] that of Australia is found partly in bedded veins and partly in fissure veins in palæozoic rocks;[36] the gold of California occurs in deposits of various kinds enclosed in "almost every kind of crystalline rock known, including the eruptive and metamorphic series, exclusive however of the two extreme types of acid and basic rocks, viz., the obsidians, vitrophyres and other glassy rocks on one side, and the ultra basic rocks, gabbros, norites and basalts on the other." Mr. W. H. Storms, M.E., from whose paper on the Wall Rocks of California Gold Mines the foregoing sentence is taken, states that "a great many veins in California are wholly within the granite, and these in the aggregate have produced a large amount of gold."[37] There is nothing therefore either in the associated minerals or the rocks enclosing the veins to suggest that the gold deposits of the Rainy Lake region will not equal in productiveness those of other mining regions. Up to the present however all that has been done has been of the nature of prospecting, and it would be rash to make confident assertions regarding the future of a region where the deepest mine is not yet down 100 feet, and only one five-stamp mill has been at work, and that for only a few months. Thus far one is justified in saying that the prospects are good for many of the locations on bedded veins in the Keewatin schists, and especially bright for the fissure veins in granite at Shoal lake, which are probably the most promising gold deposits in Ontario.

Large extent of the gold field.

During the summer gold claims and locations were examined from Pipestone lake on the west to Partridge lake on the east, a distance of over 100 miles, and from the Little America mine on the south shore of Rainy lake to the Wabigoon mine, 70 miles to the north. The gold deposits of the Lake of the Woods region come within 50 miles of Pipestone lake, and it is not unlikely that gold will be found in the intervening Keewatin schists, which have hitherto been little explored. Gold was found years ago at the Huronian mine and various points on the Shebandowan to the east of the region examined, and has been discovered recently near Ignace to the north of the Canadian Pacific. There is no reason to suppose that the many bands of Keewatin rock to the north of the present region will not prove auriferous

[34] Kemp, Ore Deposits of the U.S., p. 217.
[35] Ibid., p. 252.
[36] Phillips, Ore Deposits, p. 463 and p. 475.
[37] Engineering and Mining Journal, Feb. 23, 1895, p. 172.

when carefully explored. Grouping the Lake of the Woods region with that of Rainy lake and adjoining lakes and rivers to the north and east, we have a gold field 200 miles in length, from the Lake of the Woods to lake Shebandowan, and 70 miles in width, from Rainy Lake City to Wabigoon or Ignace. Of course much of this great area is barren Laurentian, but probably one-third is Huronian and worthy of the attention of prospectors.

Conditions in favor of the field.

When it is remembered that this gold field is not in the heart of Africa, nor in an Australian desert, nor in remote valleys of the Rocky mountains, where access is difficult, but in the most populous province of Canada, and touching at its southern edge the enterprising state of Minnesota, it seems as though its value should quickly be proved; and if it be really as productive as present appearances indicate, a year or two should see the development of a prosperous mining community. As to physical conditions, the region has everything in its favor, plenty of good water and several fine waterpowers, a large amount of still unburned timber for building and mining purposes, a wide area of the best unoccupied farming land in America close at hand to supply the necessary food products, and a climate which is admirable in summer, somewhat rigorous in winter, but always thoroughly healthy. No part of the region is more than 60 or 70 miles from a railway, and steamboat communication is available in many parts. If the district is proved to be of importance, lying as it does between two of the most enterprising cities of the continent, Duluth and Winnipeg, it will speedily have all the railway accommodation needed.

Cause of the absence of placer gold.

There is one serious drawback as a gold mining region, a drawback shared by the rest of eastern North America, in that no placer mines have been or are likely to be discovered. It is true that a few surface deposits due to the weathering of gold bearing veins have yielded gold on panning, and that there are reports of the auriferous character of some alluvial deposits on Shoal lake; but the almost clean sweep made by the glaciers of the Ice Age has probably removed the sands and gravels that might have afforded placer gold and mixed them with overwhelming amounts of barren drift. That the absence of placers however does not always seriously hamper the development of a gold region is proved by South Africa, which bids fair soon to be the greatest gold producing country in the world, though none of its mines are placers.

Mistakes that should be shunned.

In the development of this new Ontarian gold region it is to be hoped that the errors which have brought failure in other parts of the province will be avoided. Every new gold field presents new conditions and must be looked on as an experiment until the methods best suited to the treatment of its ores have been determined. We have already proved in Ontario that there is a danger in new inventions in the way of reduction plants, no matter how attractive they may appear in the glowing descriptions of interested agents. One who is tempted in this way should, before buying, make a visit to the rusting failures to be seen at most of the mines near Rat Portage, where thousands of dollars have been squandered on useless inventions, and where the only working plant is an orthodox stamp mill. Up to the present however, there seems to be no tendency in the Rainy Lake region to experiment with novelties, since all the mills talked of are stamp mills. But there is another

error into which many of the enterprising property owners of the district seem in danger of falling, that of spending money on a stamp mill before sufficient exploratory work is done. Until a mine has been so far developed as to disclose bodies of ore sufficient to pay for the mill itself, there is serious risk in investing in one. If, as the report goes, three stamp mills have been brought into the Seine country this winter, it is to be feared that too little development work has been done to assure success, and a failure which may cast doubt on the whole region is not impossible. Probably many of the bedded veins of the Keewatin, while carrying comparatively rich ore, will prove too small to pay for the erection of a stamp mill; and doubtless some mistakes will be made, and some losses incurred on this account. It is greatly to be desired that custom mills should be built at convenient points within easy reach by water of the mines on the Rainy lake and Seine river, as well as on the Manitou. In well equipped modern mills of fair size the work ought to be done far more economically than in small five-stamp mills like that at Rainy Lake City, where the cost of milling, $7 per ton, seems quite excessive. Such mills have worked very successfully in the western states, and should prove a boon to miners in a small way in the Rainy Lake region, since their properties could thus be thoroughly tested without the heavy expense and risk of putting up a stamp mill; and in many cases it would probably pay better to sell the ore than to mill it on the property.

Utility of custom mills.

Other Economic Minerals of the Rainy Lake Region.

While the gold of Rainy lake is at present by far its most valuable asset, there seems little doubt that at some time several other economic minerals may prove of importance, and during our summer's work everything of the kind which lay in our way was briefly examined. Lawson in his report, so often quoted from, says:

Lawson's list of certain and possible minerals.

"Deposits of iron may confidently be looked for. Indeed on Seine river good indications of iron ore have already been discovered, and further up the river, beyond the limits of the region mapped, valuable deposits have been found on the Atik-okan. Iron pyrites, copper pyrites and arsenical pyrites are very common in small quantities in the Keewatin rocks, and will doubtless some day be found in valuable deposits in some portion of the belt. Lead and zinc ores may also possibly be discovered. The occurrence of bosses of serpentine suggests the possibility of diamonds, and some enterprising prospector may yet be rewarded for a close examination of the vicinity of the serpentine rocks indicated on the map, or of others that may be discovered, particularly if they be found near the carbonaceous schists that sometimes occur in the Keewatin. Asbestos should also be carefully searched for in these serpentine rocks. Poor varieties were observed in veins in the serpentine of Clearwater lake. Closer inspection may reveal the finer and more valuable varieties. Good soapstone is not uncommon in the Keewatin rocks, and will some day be of value. Some of the siliceous schists would make good whetstones, and the finer textured felsite schists good hones. The development of these varied resources will however only come with the gradual settlement of the country,

as it is only the discovery of the more valuable metals in large quantities that will create a sudden influx of prospectors and mining population."

All of the minerals referred to in the above quotation undoubtedly occur in the Rainy Lake region, with the probable exception of diamonds. That even they are present in small numbers is by no means impossible. Diamonds of good quality, though few in number, have been found in the glacial deposits of Wisconsin; and it is suggested that they came originally from the vicinity of Pigeon river on the boundary of Ontario,[39] so that there probably are diamondiferous rocks in the province. It may be doubted however if another Du Toit's Pan or Kimberly is likely to be found in western Ontario. Nor is there any evidence up to the present that zinc or lead or copper ores exist in important amounts in the region, though they are all associated with the gold quartz to a greater or less extent. Arsenical pyrites was seldom observed by us, but no doubt exists in small quantities, as in the neighboring Lake of the Woods region. Iron pyrites is found in quantities that may prove important in the future on the shores of Nickel lake, between Grassy portage and Rice bays. On 577P and 580P under a thick gossan of brown iron ore one finds masses of solid pyrites several square yards in extent and more than a foot in thickness. As little or no stripping has been done, one can hardly form an idea of the extent of these deposits. The mineral exists as a rather coarse granular mass in which the usual cubes may be seen. As it is common iron pyrites, and not pyrrhotite, the name "Nickel" lake is misleading, and it is probable that the locations were taken up there under a misapprehension. An assay of this pyrite showed no gold.

Diamonds.

Iron pyrites.

Pyrrhotite, or magnetic pyrites, occurs however in the region, and specimens were obtained from the Stonedam portage, on the east side of Pipestone lake, where a deposit of this mineral 10 feet wide is interbedded with the schist. No copper pyrites was observed with it, a point in which it differs from the Sudbury pyrrhotites; but the results of an assay showed only 0.16 per cent. of nickel, though specimens from a greater depth might give better results, as often happens with nickel ores. The rock with which it is associated is a very rusty Keewatin schist.

Pyrrhotite.

At the southeast corner of the Bay of Islands, Bad Vermilion lake, a small coating of the rosy erythrite or cobalt bloom was found in a quartz vein. This is the only example of a cobalt mineral obtained in the region. Is it the "Bad Vermilion?"

Cobalt bloom.

The most important of all the ores in the region, except those of gold, are the magnetites, which occur in considerable amounts on Seine bay and in much greater quantities on the Atik-okan, 80 miles to the east. A number of iron locations were taken up on Seine bay several years ago. On 213X, the only one visited by us, masses of tolerably pure magnetite occur in a dark green, coarse grained hornblendic rock, apparently massive. The way in which the ore occurs suggests the variety of segregation out of the magma of a basic eruptive rock described by Vogt in Scandinavia. How extensive these deposits are we did not determine. It is worthy of note that some of the basic rocks of the region contain enough magnetite to make the compass

Magnetic iron ores.

[38] Report on the Geol. of the Rainy Lake Region, p. 180 F.
[39] W. H. Hobbs, Am. Geologist, July 1894, p. 31.

useless. This is well illustrated at a point to which my attention was drawn by Mr. T. R. Deacon, O. L. S., between lots 10 and 11, third concession of the township of Halkirk. Mr. Deacon supposed that there must be a considerable mass of iron ore at the spot, since the compass with which he was running a line refused its duty there. We found that the rock itself, a greenish gray schist with disseminated particles of magnetite, had a decided effect on the compass even in small fragments, so that there was no need to suppose a mass of magnetic ore beneath the surface.

The Atik-okan locations.

The most important iron ores yet discovered are on the Atik-okan, a tributary of the Seine coming in from the east near Steep Rock lake. The best known location is that of the McKellars at Iron mountain. This ridge, rising at points more than 100 feet above Atik-okan creek, may be seen by canoe voyagers for a considerable distance as a bare brown cliff. The ridge is comparatively narrow and corresponds to the strike of the gray green Keewatin schist, running a little north of east and south of west, as inferred from the position of the sun, since a compass is there of no use. The dip is nearly vertical. The whole rock is heavily charged with magnetite, and some beds or irregular masses, separated by strips of decomposed schist, are of the pure ore. One body of ore is a natural magnet. Any fragment broken off shows polarity and attracts particles of magnetite. The direction of polarity varies greatly from point to point, as shown by a pocket compass; but the poles seem to point generally east and west parallel to the strike of the ridge. In a transverse opening in the bed it was found that the ore attracts the north pole of the compass on one side and the south pole on the other, both very strongly. However a little experimentation proved that there were local poles toward which the compass was greatly deflected from all sides; and apparently these poles are irregularly arranged. There was no evidence to show that these masses of ores had been magnetized by induction from the earth's magnetism, as is sometimes assumed, for the poles, as shown by the compass, seemed to have no reference to the direction of the meridian. It was discovered a day or two later that the pocket compass used in the experiments had its polarity reversed, the south pole now pointing north.

Judging from the brief examination given to the "Iron Mountain" one may say that there is undoubtedly an immense mass of fairly pure ore, though many parts are somewhat mixed with the green schist and in a few places iron pyrites may be seen. A thin section of the country rock proves that it is an actinolite schist. Mr. Peter McKellar in his evidence before the Royal Commission states that the ore "averages 64 per cent., and lots have been got that will go 70 per cent."[40]

Similar deposits have been found a few miles further down the Atik-okan, where the Wiley Brothers of Port Arthur have done some exploration with a diamond drill. At present of course these iron ores are not available, since they are 30 miles from the nearest point on the Canadian Pacific Railway, in a region approachable only by canoes. Railways built to open up the gold region may however help these ores to a market.

[40] Report on Min. Resources of Ontario, p. 144.

Soapstone.

There are also several non-metallic minerals which will in all probability be of value at some time. Soapstone or steatite of fair quality is found at several points in the Keewatin schists, e. g. at Rock Island bay in Watten township, and near the northern end of Pipestone lake. Up to the present this material has been used only by the Indians for making pipes, which are often very ornamental. The mineral is pale greenish gray, fine grained, and shows scales of talc somewhat mixed with magnetite and dolomite. Little cubes of iron pyrites occur in some specimens. Pure foliated talc has not been observed in the region.

Serpentine and Asbestos.

Lawson has called attention to several occurrences of serpentine, as at the south end of lake Despair and the north end of Clearwater lake. This rock is very dark gray and dull in color, so as to have no value as an ornamental stone, but in the outcrop at the north end of Clearwater lake a fibrous variety shows itself, which suggests the possibility of finding chrysotile, or what is usually called asbestos. The specimens obtained at this point are coarsely fibrous and quite brittle, but they may have been injured by the forest fires which have raged along that part of the shore, since the amount of combined water, as determined in our laboratory, is only 12.68 per cent., while the normal percentage of water is about 13.50. It is well known that a slight lowering in the percentage of water is associated with brittle fibre in the famous Thetford district in the province of Quebec, which supplies most of the asbestos of the world.

Muscovite.

Another mineral that may be of value is muscovite, white or potash mica, which occurs in the coarse grained dykes of pegmatite penetrating the Laurentian and sometimes also Huronian; though up to the present crystals of large enough dimensions to be useful have not been observed. From the adjoining Lake of the Woods region fairly large sheets of excellent muscovite have been obtained.

Building and ornamental stones.

Many of the rocks of the Laurentian would furnish good buiding stone, quite as good as the gneisses quarried near Rat Portage; and some, like the handsome porphyritic biotite syenite at the lowest rapids on Sand Island river, would furnish fine ornamental stone suitable for monuments, etc. The rich appearance of this rock with its large, deep red felspars in a gray ground could not fail to be striking on a polished surface.

Absence of limestones.

One serious lack in the mineral resources of the region should be mentioned, however; that is the almost entire absence of limestones. Lawson mentions the limestone boulders which are numerous in the drift deposits along Rainy river, and have been burned for lime in some instances; but beyond this he refers only to a few impure layers of crystalline limestone, or perhaps rather dolomite, among the green schists on Manitou lake. As the region fills up with settlers this lack will be more or less felt.

Clay and sand.

Among the drift and alluvial deposits clay is very common along the river bottoms, and brick are already being manufactured on a small scale. Beds of sand are not common, though shore deposits, like that at Sand Point island, will probably suffice for local needs; so that all needful building materials except lime will be readily obtained.

STRATIGRAPHY AND PETROGRAPHY OF THE RAINY LAKE REGION.

In the previous portion of this report the economic side of the work has been taken up, and it is now proposed to consider a number of points of more purely scientific interest. No attempt will be made to cover the ground exhaustively, since those desirous of studying the matter in detail may refer to Dr. Lawson's excellent report; but an outline of the subject will be given, and anything of special interest will be discussed at greater length. The rocks will be taken up in ascending order, Laurentian, Couchiching and Keewatin; and the name Laurentian will be retained, although the rocks thus designated have been proved to have consolidated at a later period than the overlying schists. The statements of Lawson regarding the eruptive relationship of the gneisses to the Huronian rocks above have been fully borne out by our investigations in the region; and we must suppose that by the deposit of perhaps ten miles thickness of Couchiching and Keewatin rocks combined,[41] the isogeotherms, or levels of equal temperature, gradually ascended toward their normal distance from the surface; and as a result the once solid Laurentian was brought into a condition of igneo-aqueous fusion, or semi-

Study of the rocks.

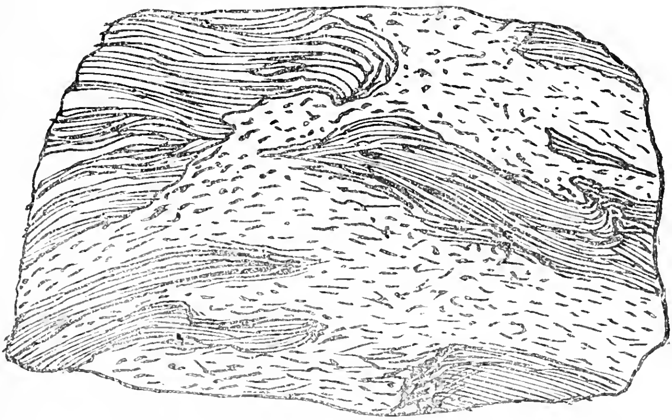

Fig. 7. Contact of Granitoid Gneiss and Couchiching. Goose Island, Rainy lake.

fusion, welling up at some points, and at others allowing the schists resting upon them to sink into sharp anticlinal folds. That fragments of the solid schists were thus broken loose and floated away, and that apophyses, irregular veins of molten matter, were injected into fissures of the rocks above, anyo e may satisfy himself by a day's canoeing among the islands in the eastern part of Rainy lake, where the two formations are in contact.

THE LAURENTIAN ROCKS.

The Laurentian rocks consist partly of granite and syenite, but chiefly of granitoid gneisses of a composition corresponding to granite, syenite or quartz diorite, having a more or less distinct foliation, parallel as a rule to the strike of the schists enclosing their rounded areas. There are instances however, as on the west side of Bear's passage, where the Laurentian is seen cutting across the schist planes of the Huronian.

Laurentian gneisses of the district,

[41] Report on the Geology of the Rainy Lake Region, p. 47 F, 102 F, etc.

and their difference from gneisses of other regions.

It is worthy of note that these gneisses differ greatly from some typica Laurentian gneisses of other regions, e.g., the Thousand Islands, where one finds in many cases great and sharply defined variations of mineral composition, one layer quartzose or pure quartz, another felspathic, a third micaceous or hornblendic, each with little or no gradation into the other, and all folded and contorted. In the Rainy Lake region, so far as observed by the writer, the gneisses have not this character. They sometimes present variations corresponding to the *schlierige structur* of massive rocks, resulting from the action of flow upon a magma having differences of basicity in various portions, or having portions of schist torn off and partially dissolved. The only characteristic examples of gneiss resembling the typical Laurentian of some eastern localities observed by the writer were found along Sand Island river, a few miles below Little Turtle lake. Is this a remnant of original Laurentian gneiss which escaped fusion?

Types of Rainy Lake Laurentian.

There are several types of rock found in the Rainy Lake Laurentian, some granitoid in appearance, others porphyritic. The granitoid rocks are sometimes gray and verge towards quartz diorites, and at others whitish, yellowish or flesh colored. The gray granitic rocks contain usually little quartz, a good deal of orthoclase or microcline, much plagioclase with a small angle of extinction from the twin plane and a distinct zonal structure, and a considerable amount of brown biotite and green hornblende, the latter, as mentioned by Lawson, sometimes having the look of a secondary mineral, and probably representing augite. The felspars have a tendency to idiomorphic form, and sometimes might be called porphyritic. Undulatory extinction and cataclase structure are commonly to be found. These rocks, in spite of their slight foliation, may be classed as massive, and range from plagioclase granites to quartz diorites. To this group belong specimens collected at Fort Frances, Gash Point, Rest island, Angling island, and the very gneissoid rock northeast of Redgut village.

Granitoid gneisses.

The flesh colored or yellowish variety differs from the last in containing more quartz, orthoclase and microcline, less plagioclase, and muscovite, sometimes accompanied by biotite. They are granites proper, or perhaps in some cases aplites. Their felspars have the usual tendency to form porphyritic crystals, and the striated ones show more or less zonal structure. Evidence of the action of crushing or shearing strain is to be found in broken crystals and undulating extinction. Examples have been found near Bear's passage, Gash Point, and on islands in Swell bay. It is possible that these rocks should be looked on as belonging rather to the eruptives than the gneissoid group. They sometimes cut across the schistose structure of the overlying Huronian, as at Bear's passage; and they show few traces of foliation. A rock from the west shore of Pickerel lake, mapped by Lawson as eruptive, has some points of likeness to this group. A specimen of rather dark flesh color from a peninsula on the south shore of Furlonge lake should also be grouped here in all probability, though the micas are too much weathered to be determined, and the quartz is more greatly crushed than in any other sections examined. One example collected on an island (Location 166T) in Swell bay, contains a sharp edged fragment of gray Couchiching schist surrounded by a half inch

margin of granite much whiter than the rest. A thin section disclosed no difference in composition in this bleached rim, except the absence of the small amount of biotite and iron oxides found in the rock generally. Some very schistose gneisses from the east shore of Rocky Islet bay turn out to be simply crushed and sheared granites of the type just described. The distinctly porphyritic gneisses also include a darker, more basic series, and a flesh colored, more acid one; in both however the porphyritic appearance is caused by the presence of large crystals of felspar, often Carlsbad twins. These have commonly an oblong or somewhat rounded oblong shape, but may be tailed out at each end, forming *augengneiss*. The size of the porphyritic felspars varies greatly, a half inch being the usual length, the largest observed, about 2½ inches long, occur at the lowest rapid on Sand Island river. The ground mass is generally coarse grained and distinctly schistose; and, as noted by Lawson, the porphyritic felspars usually have their longest diameters in the direction of the schistose structure.

Porphyritic gneisses, and

Under the microscope the darker porphyritic gneisses are found to consist of quartz in rather small amount, orthoclase and microcline, a little plagioclase and biotite or hornblende, sometimes both. The biotite, as Lawson has shown, very commonly weathers to epidote, which forms large yellow crystals. Titanite is a common accessory mineral. The porphyritic felspars, so far as observed, are never ordinary plagioclase, as in the basic variety of the more granitic Laurentian rocks, but often microcline with microperthitic inclusions of albite. Embedded in the microcline one finds many black needles, perhaps rutile, brown rows of dots or scales and long prisms of apatite. In one case a well formed twin of brown hornblende was found completely enclosed in porphyritic microcline. The rim of the porphyritic crystals is irregular, and generally bordered by a layer apparently of crushed quartz and felspar. Frequently, at the very edge of the crystal, the felspar is penetrated by quartz, forming the micropegmatite structure, which in this case seems to be caused by the strains which have acted on the rock.

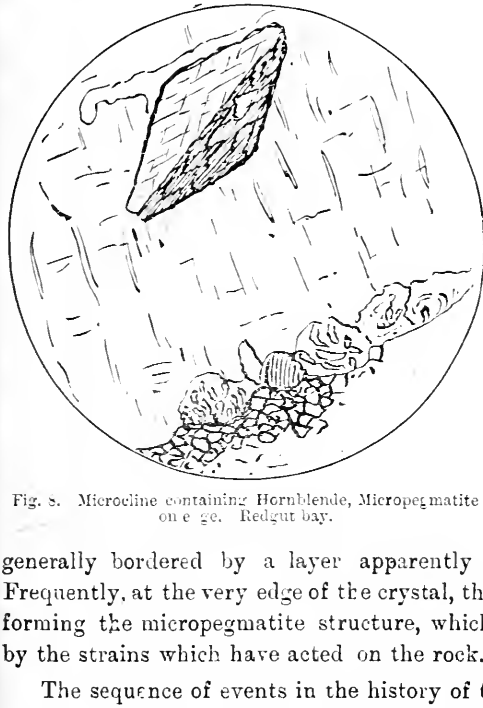

Fig. 8. Microcline containing Hornblende, Micropegmatite on edge. Redgut bay.

The sequence of events in the history of these porphyritic syenite gneisses seems to include first the crystallization of basic substances as apatite, rutile and sometimes hornblende and biotite; immediately after this, or partly coincidently with it, microcline took crystalline form. Then cooling was accelerated, perhaps by the convulsions accompanying the nipping in of the Huronian and the fissuring and partial dissolving of the overlying schists;

Sequence of events in their structure.

and the other constituents crystallized out, including a second generation of felspars and of the basic minerals. There was probably some motion in the mass before complete solidification, rounding the edges of the porphyritic felspars and allowing the pegmatitic intergrowth. In some cases still further motion of a shearing kind, perhaps after complete consolidation, gave rise to the *augengneiss* structure.

Good examples of these basic porphyritic gneisses are found at the Halfbreed reserve and on Redgut and Rice bays. At some points, e.g., the Halfbreed reserve, the syenitic gneiss is traversed by very fine grained or felsitic looking veins which may be two feet in width. At the reserve the larger veins have a paler selvage along the not very sharply defined edge of the coarse grained rock, and very narrow veins, sometimes not over an inch wide, intersect both. The latter have darker selvages and a structure suggesting a shearing motion of the syenite walls. Under the microscope the fine grained rock is thoroughly granitic in appearance, and differs from the gneiss mainly in having more quartz and less of the basic minerals and no porphyritic felspars. These veins are probably of the kind sometimes called "segregation veins," where the fissures have opened before the complete solidification of the enclosing rock and more siliceous portions of the magma have exuded into them.

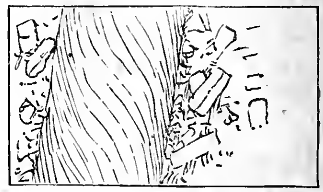

Fig. 9. Vein of very fine grained or felsitic Granite in Porphyrite Syenite Gneiss. Halfbreed Reserve, near Fort Frances.

The flesh colored porphyritic gneisses have in general the same constitution as the syenitic ones, but with different proportions of the more important ingredients, quartz being more abundant and biotite and hornblende much less so. Some examples have a considerable amount of plagioclase of idiomorphic form and zonal structure, thus resembling the flesh colored granites; but the large phenocrysts of microcline distinguish them. Good specimens were obtained on the south shore of Furlonge lake, at the lowest rapids on Sand Island river, and on a bay west of the Lower Manitou lake, the last being a good example of augengneiss.

Other gneisses.

There remain to be considered some gneisses having sharply differentiated layers, suggesting the type of Laurentian familiar in the eastern part of Ontario. The only examples of this kind observed are from Sand Island river, between Little Turtle lake and Redgut bay. Naturally they vary greatly in character, and their peculiarities are better studied in the field than in thin sections under the microscope. There are bands of rather dark gray rock consisting essentially of much orthoclase, a little oligoclase and a large amount of green hornblende. This rock, which is a hornblende syenite gneiss in composition, differs from all the other Laurentian rocks examined in containing no microcline, and showing no zonal structure nor idiomorphic forms in its felspar. Specimens are found not far below the outlet of Little Turtle lake. At no great distance away banded gneiss consisting of very micaceous and very felspathic layers occurs, which under the microscope proves to consist of much quartz, orthoclase and micropegmatite, with a little

plagioclase and biotite. At another point a pale gray, almost white gneissoid rock contains bands of quartz, and proves under the microscope to be a much crushed muscovite gneiss. It is made up of quartz, orthoclase, plagioclase and muscovite, with a trace of biotite. Some of the felspar showing no striations occurs as porphyritic crystals, often broken and re-cemented, or with parts drifted a little asunder. These crystals have a marked zonal structure, the center differing in angle of extinction from the exterior, and are probably untwinned plagioclase, since one can hardly imagine orthoclase to have such variations in optical properties. The rock just described is perhaps a very siliceous example of the acid granitic rocks sheared into a gneissoid arrangement, since the "mortar structure" is prevalent and the muscovite probably represents an alteration product of crushed orthoclase.

COUCHICHING ROCKS.

Consistence of the Couchiching schists.

The thick series of schists to which Lawson has given the name Couchiching comprises the oldest rocks of the region, resting upon the later Laurentian gneisses which have torn off fragments of them and sent up apophyses into their fissures; and underlying the series of Keewatin schists and eruptives which Lawson indicates (doubtfully) as Huronian. These monotonous, gray schists consist typically of quartz, sometimes in granular form, and brown biotite with a varying amount of felspar, both orthoclase and plagioclase. They have been somewhat briefly described by Lawson,[42] who looks on them, no doubt correctly, as altered sandy sediments. They show those rapid changes of composition in passing from one layer to another that suggest sedimentation, and in some cases the quartz of which they are so largely composed has a distinctly granular aspect, though in others the quartz particles fit into so perfect a mosaic as to hint at a deposit from solution. These fine grained mica schists and gneisses are so sharply different from the Laurentian rocks beneath that the line of demarcation is usually very distinct; though occasionally, as on Lichen island and others in the eastern arm of Rainy lake, the Laurentian is seemingly interbedded with the Couchiching. This however, as shown by Lawson, is due to the Laurentian magma having forced its way between the layers of schist. The nearest approach to a transition between the Couchiching and Laurentian is to be found on the southeast shores of Rice bay, where the writer found himself in doubt as to the classification, though Lawson maps the region as Couchiching. A specimen from near the point dividing the two arms of Rice bay has a ground of the usual mica schist containing elongated pale yellow portions having dark green nuclei. An examination of a thin section (595) shows that the bleached portions differ from others mainly in the absence of biotite and chlorite, while the dark nucleus consists of chlorite, some muscovite and magnetite. Another specimen from a point not far off has dark green and yellowish layers, the green ones containing some hornblende and epidote as well as biotite, chlorite and quartz A pale green variety contains beside chlorite and biotite cloudy patches of muscovite or sericite. Pale gray, almost white, varieties containing quartz, with some orthoclase and plagioclase and a large amount of muscovite,

[42] Geol. Sur. Can., 1887, 107 F, etc.

approach the muscovite gneisses of the Laurentian in character, and examples with only traces of the felspars occur forming muscovite schists. The muscovite gneiss resembles closely some rocks which have been described by the writer among the acid gneisses of the Laurentian, since they contain much microcline and plagioclase having at times distinctly idiomorphic forms They are apparently sheared subporphyritic granites.

Examples of contact metamorphism.

The occurrence of minerals characteristic of contact metamorphism in some parts of the Couchiching is of interest. Lawson describes certain rounded or stoutly spindle-shaped bodies (occasionally square or rectangular in outline) as consisting of an aggregate of particles of muscovite and kaolin, and as representing weathered andalusite or some allied mineral. He remarks the total absence of felspar in a rock which has undergone contact metamorphism in contact with a granitic mass as an interesting fact, comparing his observations with those of Rosenbusch at Barr-Andlau.[43]

Garnets.

Similar specimens were obtained by the present writer on the north side of Goose island; but the most striking examples were found on islands and the mainland just east of Grassy portage. On one of the islands, in a matrix of granular quartz with a little biotite, there are clusters of well formed wine-red garnets, wrapped round with dark green mica. The garnets have often transparent, doubly refracting inclusions and black grains, apparently of magnetite. On the mainland near by the mica schist is closely crowded with staurolite crystals and very small pale garnets of exquisitely perfect shape. Some of the staurolites are found on examining thin sections to be completely changed to a scaly aggregate like that described by Lawson for andalusite, but the forms of twins crossing at 60° are still distinctly preserved. In other sections the staurolite is fresher and has well defined sections with parallel extinction and strong dichroism, rich amber brown and pale yellow. It is worthy of note however that these examples of "contact of metamorphism" are apparently some distance, at least a mile or two, from the nearest Laurentian; while at many points of immediate contact the mica schist contains none of these minerals, and is seemingly quite unchanged. So far as observed the masses of Couchiching swept off by the Laurentian gneiss show few or no contact effects.

The Couchiching area.

It is probable that the occurrence of Couchiching schists is somewhat wider than has been indicated by Lawson's map; since rocks having the characteristic features of these schists, granular quartz with brown biotite, have been found by the writer in a few localities at some distance from the large Couchiching area. A specimen from the southern shore of the south-eastern end of Clearwater lake, a half-mile from its outlet, in an area mapped as Laurentian, is typically Couchiching in appearance, showing the granular look of the quartz very distinctly in a thin section (672); and the country rock of 131P on the Upper Manitou, in a region not yet mapped by the Geological Survey, seems to be of the same character. Both examples come just at the edge of the Keewatin, as one would expect. It may be that the rock from Clearwater lake corresponds to the micaceous granulitic rock which

[43]Geol. Sur. Can., 1887, pp. 107 and 108 F.

Lawson has described, from a point half a mile below Burnt narrows on the same lake, as an altered quartz porphyry, though the thin section examined by the writer shows no trace of porphyritic structure.[44]

THE KEEWATIN ROCKS.

Consistence of the Keewatin.

By far the most interesting of the series of rocks represented in the Rainy Lake region is the Keewatin, a series of eruptive and fragmental rocks of great thickness and variety, consisting broadly of a lower group of basic eruptives and volcanic ashes, and an upper acid group. The green schists and beds of massive rock of the lower group rest, so far as the writer has observed, conformably upon the Couchiching. Lawson and Winchell and Grant speak of a certain unconformity between the two as proved by the occurrence of conglomerates near the base of the Keewatin[45]; but the conglomerates appear seldom, if ever, to rest actually upon the Couchiching, and in any case contain no pebbles which can be identified as Couchiching in origin. In several localities, on the other hand, there appear to be transitions between Couchiching and Keewatin; Lawson mentioning the interbedding of the two varieties of schist at some points. Specimens of a wrinkled schist taken by the writer from the junction at the southeast end of Redgut bay seem intermediate in general appearance as well as in microscopic characters between the two series, since the rock is made up chiefly of brown mica and green chlorite, with a little quartz and probably a little felspar. However, the question of conformity or unconformity is not a very important one in this case, for the general character and origin of the two series of rocks, one apparently an ordinary clastic more or less metamorphosed, and the other eruptive and pyroclastic, mark them off by a sufficient break. If the presence of conglomerates alone is to be held as a proof of unconformity, the Keewatin itself must be split up, for conglomerates occur at more than one level in the series.

Lawson has treated the petrography of the Keewatin at considerable length,[46] and it will be unnecessary here to do more than refer to the more salient types of rock and to describe a few specimens of more than usual interest.

Diabases, gabbros and diorites.

The bulk or the lower basic portion of the Keewatin is formed of massive rocks, chiefly diabases, more rarely gabbros, sometimes apparently diorites. Many of them are excessively weathered, the felspars turned into an aggregate of epidote, zoisite, etc., and the augite into secondary hornblende or into chlorite and carbonates. In many cases too they have undergone shearing or crushing forces, so that all gradations may be found between massive, tolerably fresh diabase and aggregates of decomposition products that retain hardly a trace of the original structure of the rock. These changes are graphically described by Lawson, and a number of interesting illustrations given showing the effects of stretching and shattering upon the minerals composing the rock, so that no further account of them is necessary here.

44Geol. Sur. Can., p. 88 F.

45Ibid., 1887, p. 38 F and 84 F.

46Ibid., p. 57 F, etc.

Porphyroids.

A number of rocks having more or less the look of schistose clastics or greywacke turn out to be porphyroids, having a magma of felsitic or microgranitic habit, formed, so far as one can determine in the fresher examples, of minute interlocking felspars with perhaps some quartz and always more or less muscovite, chlorite or biotite. In more weathered ones sharp rhombohedra or irregular patches of dolomite, calcite and chlorite or biotite occur in the ground mass, and secondary quartz may be found. The porphyritic crystals are sometines, as in a specimen from the northeast corner of Lower Manitou lake, sharp and clean cut, with perfect crystalline outlines and few signs of crushing or weathering; but all stages of decay may be observed until mere clouds of an aggregate of epidote, zoisite, etc., remain. In most cases the crystals are more or less broken or rounded, and they may be drawn out into tails. When not too badly weathered to show twinning, the crystals seem almost invariably to be plagioclase, and the lamellæ have in general an angle

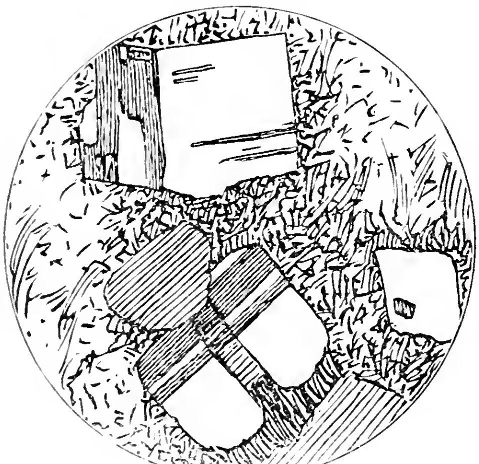

Fig. 10. Quartz Porphyrite. Lower Manitou lake.

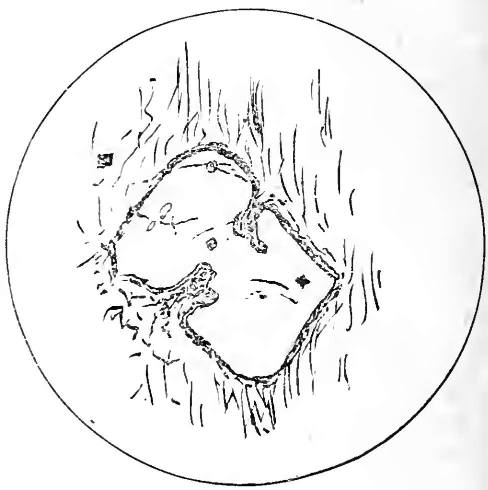

Fig. 11. Quartz Porphyrite. Rocky Narrows.

of extinction of 8° to 20° from the twin plane, where the twinning is according to the albite law, the average being 14°, indicating a composition between andesite and labradorite. In many cases twin lamellæ according to the pericline law occur also. Good examples of these more or less schistose porphyrites were obtained on the Seine river, on Lower Manitou and Cross lake. In some instances blebs and fairly well formed dihexahedra of quartz occur along with the plagioclase in sufficient amounts to justify calling the rock a quartz porphyrite. Examples were found on Cross lake and on a small island (623P) near Rocky Islet narrows. In the latter case (thin section 648) a crystal shows embayments of the magma. The rather basic character of the porphyritic felspars and also of the magma as shown by the dark color caused by the presence of chlorite or biotite in considerable amounts, and also the presence of large quantities of carbonates in some instances, marks these rocks off from the group of modified quartz porphyries included in the upper acid Keewatin rocks.

The schistose members of the basic Keewatin are often interbedded with massive sheets of altered eruptives, and are hard to separate from the more crushed and altered ones. They consist chiefly of hornblende schists near the contact with the Laurentian, and afford an examble of contact alteration, but in other localities of chlorite schists. The specimens obtained from small strips nipped in by the Laurentian, as along Sand Island river, may also contain biotite in important amounts. Thin sections (555 and 627) illustrate this well, consisting as they do almost wholly of pale blue green, faintly dichroic hornblende with scales of brown mica. In other cases, as described by Lawson, we find coarse grained hornblende schists and diorite schists, and also finer grained rocks in which the hornblende is of a fibrous, felted character, with some quartz and calcite.[47]

Hornblende, chlorite and diorite schists.

The chlorite schists have a special interest from their occurrence as the country rock of auriferous bedded veins, as at the Little America mine near Rainy Lake City, where the soft, fissile, lustrous green schist consists of fine scales of chlorite with minute particles, apparently of quartz, and irregularly distributed masses of some carbonate. Black spots of an opaque mineral, probably magnetite, complete the list. In other thin sections magnetite is much more common and shows the usual octrahedral outlines. A specimen of pale green, lustrous schist from Strawberry lake (674) reminds one somewhat in its faintly blotched appearance of *garbenschiefer*. Under the microscope with a low power it is seen to be a sort of agglomerate of paler and greener portions. With a high power both parts are found to consist of the same elements, chlorite and quartz, with a little calcite, but the greener portions contain chlorite in larger amount. In many parts of this section cloudy patches are found to be filled with minute crystals of rutile, often knee and arrowhead shaped twins.

Transitions.

It need hardly be said that transitions between the hornblende and chlorite schists are numerous. There are also paler green schists, as described by Lawson, largely charged with epidote and zoisite, forming links to a set of hard, compact, pale green rocks showing little or no trace of schistose structure and consisting chiefly of epidote and zoisite, usually with some quartz and chlorite. The latter may perhaps be called saussurite rocks, the result probably of the weathering of a basic felspathic ash. Examples of the sort were obtained on Seine bay. Along with the chlorite schists the soapstones may be mentioned. pale gray or bluish gray, slightly schistose rocks, so soft as to be scratched with the nail, used by the Indians as pipestone. Two thin sections were examined, one from the upper end of Pipestone lake (553); another from Rocky Islet bay in Watten township. The former proves under the microscope to consist of scales of talc, a little chlorite, and a considerable quantity of a carbonate, no doubt dolomite, since it does not effervesce with cold acid. Much magnetite is scattered here and there through the rock. The specimen from Rocky Islet bay (552) consists mainly of talc with the characteristic high polarization colors and tendency to rosette structure ; the only other minerals being a little chlorite and a considerable quantity of magnetite, often in small grains arranged in rows outlining areas of talc. It is probable that these

Soapstone.

[47] Geol. Sur. Can., 1887, p. 73 F., etc.

areas represent the shapes of some original mineral from which both talc and magnetite are derived. The black lines in one case run in two directions nearly at right angles to one another, suggesting perhaps the cleavage of an augite. In another instance they meet at an angle of 114°, suggesting hornblende.

Nondescript schists.

A few rather nondescript schistose rocks may be mentioned here. One of these found in Halkirk township is greenish gray, of medium grain, and so magnetic that the surveyors could not use their compasses in its neighborhood. It is interbedded with green Keewatin schists and diabases. Examined with the microscope (659) it proves to consist of tremolite with a little green hornblende, some biotite having a strong green and brown dichroism, but little difference in absorption in the two directions, much calcite and magnetite. The extinction angle of the colorless hornblende is in one case as high as 26½°, but generally not so high. Another specimen (676), fine grained and dull gray which comes from Nickel lake and forms the country rock of a thick bed of pyrite, has a microgranitic structure and consists chiefly of quartz, a little felspar, chlorite and muscovite. Tattered looking, pale garnets and pyrite occur as accessory minerals. This is the only instance where garnets were found in the Keewatin.

Non-eruptive clastic rocks.

Ordinary clastic rocks not of eruptive origin are of comparatively rare occurrence in the Keewatin, but present considerable variety, since they run from slates and greywackes to conglomerates enclosing boulders, sometimes apparently of Laurentian origin, a foot in diameter. Specimens of slate from the upper end of Pickerel lake and from a railway cutting near Wabigoon were examined, and both appear to consist of quartz, with scales of chlorite, or perhaps sericite, and many black particles probably of carbonaceous matter, in denser clouds at some points than others, but without the definite clear spaces mentioned by Lawson.[48] A specimen obtained from the narrows between Lower and Upper Manitou is slaty in appearance, but spotted with many tiny rhombohedra of calcite. Under the microscope it proves to be composed of chlorite and quartz, as to the ground mass, and to contain many crystals of rutile, but no black particles. It should therefore be placed among the chlorite schists.

Greywackes.

Greywackes from several localities, especially along the Seine river, were examined, but demand no special mention. The country rock of the Partridge mine, on an island in the lake of the same name, appears to be a greywacke, since it consists of unrounded fragments of quartz and calcite in a fine grained paste of chlorite, quartz, etc. It should be mentioned that several rocks taken for greywacke in the field turned out when examined microscopically to be sheared and weathered porphyries or porphyrites in which the crystal form of the felspars was still preserved.

Agglomerates and conglomerates.

Nothing need be added to the description given by Lawson of the agglomerates and conglomerates, though the question of the source of the pebbles of granite, gneiss and quartz porphyry in the latter is an interesting one, since the Laurentian rocks of the region have been proved to be of *later age*

[48] Geol. Sur. Can., p. 94 F.

than the conglomerates. Probably Lawson's suggestion that they may have come from rocks then solid that were later brought into igneo-aqueous fusion to form the present Laurentian gneisses, is the most probable solution of the problem.[49]

ACID KEEWATIN SCHISTS AND PORPHYRIES.

The acid group of Keewatin rocks, including mainly felsites or sericite schists and quartz porphyries, appears as a whole to be younger than the green schists and massive rocks of the Keewatin. In most parts of the region there is no indication of unconformity between them, and often the two varieties of schists are more or less interbeded at their contact. In a few instances however there are distinct proofs of a want of conformity. The best illustration of this was found just south of the entry into Upper Manitou lake, on the west shore of the long reach from Lower Manitou. Here a vein of yellow schistose rock about six feet wide cuts across the strike of the green schists and sends apophyses into them. The schistose structure of both rocks is well marked, especially in the green schist, and the direction of cleavage runs with uniformity across the dyke ot yellowish rock. Specimens from the dyke show a nacreous lustre on the cleavage surfaces and contain many blebs of quartz. In spite of its well marked schistosity the rock is a typical quartz porphyry, as proved by the examination of a thin section (575). There is a colorless, felsitic ground mass of the usual kind, but crowded with sericite scales having a parallel arrangement. The porphyritic minerals consist of quartz, sometimes dihexagonal pyramids with embayments of the magma, now and then broken and having undulatory extinction; orthoclase, untwinned or as Carlsbad twins; and plagioclase in about equal amount, having an angle of extinction from twin planes ranging from 12° to 18°, and therefore somewhat more acid than labradorite. The felspars usually present sharp crystalline form, but are sometimes broken, and are always considerably weathered. The scales of sericitic do not wrap around the porphyritic crystals, but keep their parallelism and stop short in contact with them. Some masses of a carbonate surrounded by brown oxide of iron are to be found scattered through the ground mass.

Felsites and quartz porphyries.

Fig. 12. Eruptive vein of Felsite Schist, 6 feet wide, in Green Schist. Upper Manitou lake.

Not far from the dyke just described there is a bedded vein or dyke of similar rock having in general the same strike as the green schists on each side, but sending off apophyses, showing that it is of irruptive character. It is not so schistose as the last, contains less sericite, and the felspars have succumbed more completely to crushing, while the quartz crystals have often survived almost unhurt. In these two instances it appears that the schistose

[49] Geol. Sur. Can., p. 85 F.

structure has resulted from pressure pure and simple, since there is no evidence of shearing motion. They also make it clear that, at least in some cases, the schistose structure, and hence the strike of the schists, has nothing to do with an original stratification. The lower Keewatin rocks of Upper Manitou must have been solidified, and have been fissured before these dykes of Upper Keewatin were injected into them. Are these quartz porphyries effusive varieties of the same magma which solidified as gneisses underneath the green Keewatin? Whether or not they have the same origin as the gneisses, they must have been poured out before the final series of convulsions by which the Laurentian nipped in the folds of Keewatin of which the felsites form a part.

All gradations exist between quartz porphyries such as those described and felsites or sericitic schists in which the porphyritic crystals have been almost completely destroyed. Some of these schistose rocks may however have been originally felsites devoid or nearly so of the porphyritic structure. Examples occur in which quartz crystals are rare or absent and the prevalent felspars are plagiocalse, thus affording transitions to the quartz porphyrites. When the ground mass includes biotite, and no orthoclase phenocrysts occur, we must call the rock mica porphyrite, as in the case of specimens previously described from the Seine river. The felsite schists and agglomerates have been sufficiently described by Lawson,[50] and will receive no further mention here.

Mica porphyrite.

Fig. 13. Deformed basal section of Quartz, showing fine cracks. Clearwater lake.

GRANITE BOSSES.

Granites in Keewatin areas:

At numerous points in the region granite projects through both Laurentian and Huronian as small or large bosses. No examples of granite surrounded by the Laurentian have been studied microscopically by the writer, but considerable attention has been paid to those occurring in areas of Keewatin. Some rather interesting granites, which have been described by Lawson from Pickerel lake,[51] were found to have an unusual relationship of the felspars. In a section from the west shore (620) a first generation of idiomorphic plagioclase, very finely striated (anorthoclase?) and with traces of zonal structures, was followed by the crystallization of microcline and quartz filling in the spaces. Well-formed plagioclases are completely enclosed in large crystals of the later felspar. In a thin section (637) from the east

at Pickerel lake,

[50]Geol. Sur. Can., p. 85F, etc.
[51]Ibid. p. 145F.

side of the lake it appears as though crystals of finely striated plagioclase had formed a nucleus about which the microcline was deposited in parallel crystallographic position. The outline between the two is sharply drawn, and the microline is quite unweathered, but the plagioclase (or perhaps anorthoclase) contains scales of muscovite parallel to the longest axis of the crystal, and has a number of epidote crystals heaped at its centre.

A boss of granite somewhat different in character was found by the writer covering more than a square mile between Caribou lake and Manitou. It is a coarse-grained, flesh-red rock bordered by a rim of blackish flesh-red, schistose rock where it touches the green Keewatin schists. In thin sections one finds quartz, orthoclase, often with microperthitic inclusions, plagioclase and a little biotite, mostly weathered into chlorite, as the essential minerals; and apatite and titanite as accessories. The plagioclases have narrow twinning, a low angle of extinction from the twin plane, and a tendency to zonal structure. They are at times idiomorphic. All the minerals show traces of strain, and in a thin section from the darker edge, where the boss seems to have mingled with the green schist, there are lines of crushing where nothing is left but an aggregate of particles. The chlorite schist from the contact seems to have suffered no metamorphism, unless the accumulation of black specks, probably of magnetite, in dark streaks and whorls is to be looked on as a result of metamorphism.

between Caribou and Manitou lakes.

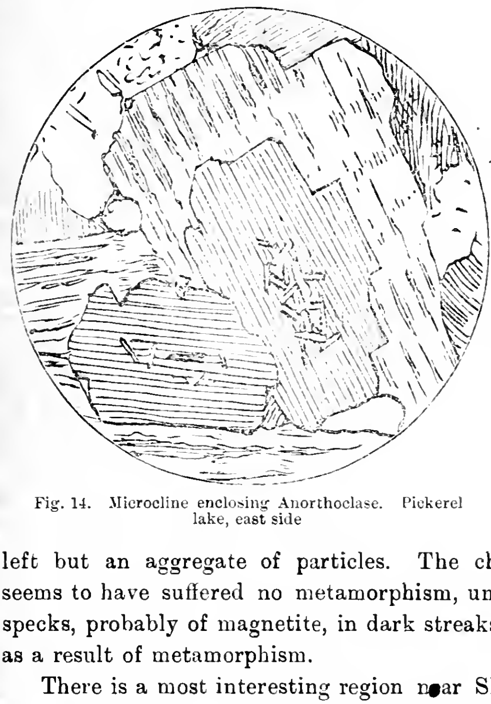

Fig. 14. Microcline enclosing Anorthoclase. Pickerel lake, east side

There is a most interesting region near Shoal and Bad Vermilion lakes, where at least three bosses of granite of irregular shape are associated with anorthosite. These granites are rather coarse-grained and vary in tint from flesh color to a greenish gray. Some of them from the shores of Bad Vermilion river are mottled with lighter and darker greenish portions, but thin sections show comparatively little variation except in the amount of biotite or its decomposition product, chlorite. Examples of these rocks have been studied by Lawson[52] and by Winchel and Grant,[53] the latter writers paying special attention to the area with which the Wiegand-Ray gold veins are associated. In general the rock is very quartoze and a large quantity of plagioclase occurs with the orthoclase. The quartz has the usual granite appearance, and shows the effects of strain in undulatory extinction and broken crystals. The felspar is badly weathered in all the sections examined, so that one is sometimes in doubt whether orthoclase or plagioclase is present;

and near Shoal and Bad Vermilion lakes.

[52] Geol. Sur. Can., p. 146F.
[53] Geol. and Nat. Hist. Sur. Minn., part III., 23rd An. Rep., p. 58.

but in many cases the latter seems to preponderate. The plagioclase is finely striated and sometimes displays a zonal structure and idiomorphic form. The darker mineral is generally biotite or its decomposition products, chlorite and epidote. In two sections (570 and 573) from Bad Vermilion river the biotite and chlorite make up more than a third of the rock ; but in most others the green minerals are present in very much smaller proportions. The chlorite in 573 contains many rods and knee-shaped twins of rutile, rich brown yellow in color. One specimen from Bad Vermilion river (572) is made up chiefly of plagioclase, quartz and hornblende, the last mineral being in large amounts. It should perhaps be named quartz diorite, since no orthoclase can be recognized with certainty, though the plagioclase of this specimen is of the same type as that of the neighboring granites.

Other granite localities.

It is probable that careful search would reveal many other outcrops of granite in the Keewatin area. A medium-grained, greenish gray rock obtained on the west shore of Seine river a half mile below its mouth, proves, on examining a thin section (557) to be a granite rich in plagioclase and containing some chlorite, on the whole very like the Bad Vermilion granites, though the quartz is rather more crushed. Greenish gray granite has been obtained also on the Little Canada island, close to an auriferous quartz vein. A thin section (534) shows that it is made up of quartz, orthoclase, plagioclase, and a little chlorite associated with magnetite. It differs from the previous granites in habit, since the quartz and felspar, chiefly plagioclase, are generally intergrown, forming a rough pegmatitic structure, in which the plagioclase seems to have formed in a sense skeleton crystals, one or more individuals of quartz filling in the spaces. The country rock enclosing a large quartz vein, said to be auriferous, on the shore of Partridge lake, a long way east of the localities previously mentioned but apparently on the same band of Keewatin, resembles the rocks previously described, though it is darker green gray in color and even more weathered. In a thin section (531) one finds much quartz of the granite type, badly weathered felspar, some of which shows narrow twin striations, calcite and a considerable amount of chlorite and epidote, the last three minerals being associated and no doubt representing some basic silicate.

Fig. 15. Plagioclase, shaded in direction of striations, quartz white, lower part a single individual. Little Canada island.

GABBRO AND ANORTHOSITE.

Lawson includes certain gabbros with the diabases and other rocks of the lower Keewatin. It is however a little surprising to find these two rocks intermingled as if of the same age and formed under the same conditions. If it be true, as generally held, that diabase and other rocks having the ophitic structure have solidified under special conditions, including a comparative absence of pressure such as would be found at or near the surface of the earth, and that gabbro with other rocks of the granite type have solidified under quite different conditions, including an enormous pressure of overlying rock; one might infer that the two rocks could not have been formed at the same time in the same place. It is possible that the outcrops of gabbro in the Keewatin are always intrusive and of later age than the Keewatin diabases, but much detailed field work would be necessary to establish the fact. The mention by Lawson of rocks intermediate between the two, e. g. at Berry Island,[54] suggests that the whole series may be of approximately the same age and formed under the same conditions. Only two thin sections of gabbros, seemingly belonging to the Keewatin series, have been studied by the present writer; and since they present no points of special interest we may turn directly to the gabbros and related rocks that have undoubtedly pushed their way through the Keewatin as plutonic bosses. These have been studied specially in the Bad Vermilion and Seine river district, where they cover a considerable area in conjunction with three granite bosses, forming, according to Lawson, the eroded basis of a Keewatin volcano or group of volcanoes, from which part of the volcanic ashes and outflows of trap so characteristic of the Keewatin was derived.[55] The rocks of this area include some curious green and mottled porphyritic gabbros, or perhaps porphyrites, having a green ground mass crowded with well formed greenish or white plagioclase crystals; and also a large amount of anorthosite. The porphyritic rock occurs along the northwest shore of Bad Vermilion lake. Specimens obtained there contain felspars $\frac{1}{3}$ or $\frac{1}{2}$ inch long, sometimes tabular and rather thin, at other times stout and of a square shape. In some places however these felspar crystals so crowd one another as almost to exclude the green mineral forming the magma. Twin striations are readily seen on cleavage planes. Under the microscope (sections 514 and 515) one finds that weathering has progressed very far, the more basic mineral, no doubt some variety of augite, being completely changed to calcite and chlorite; while the felspars are sometimes reduced to aggregates of epidote and zoisite, and at others are filled with green chlorite, leaving only a rim and skeleton of unchanged plagioclase. These skeletons however sometimes have retained their freshness, so that twin striations are readily distinguishable. The extinction angles measured from the twin plane range from 9° to 14°, indicating a felspar more acid than labradorite; but only three measurements were made, and too much stress should not be laid on the result.

A question of their relative ages.

Intrusive gabbros and related rocks in the Keewatin,

in the Bad Vermilion and Seine river districts,

Lawson describes the rock on Bad Vermilion lake as "in many places, a fine white rock, resembling at first sight a coarsely crystalline marble. It is

and on Bad Vermilion lake.

[54]Geol. Sur. Can. 1887, p. 65F. [55]Ibid. p. 57F.

however much harder, and is for the most part mottled with the pyroxenic constituent. Under the microscope there is little to be noted, save that the anorthite is almost entirely changed to the aggregate of zoisite and albite, known as saussurite, and that the pyroxene is non-pleochroic and rhombic, though much decomposed, and difficult to determine accurately."[56] He names it a saussurite gabbro. Later he refers it, no doubt correctly, to the anorthosites of Dr. Adams, though he spells the name after the fashion of some American lithologists, anorthosyte.[57] Specimens of this rock collected at the upper end of Bad Vermilion river and on the shore of the lake near by answer to this description. The felspars here and farther north near the eastward bend of the lake are distinctly porphyritic, the outlines often corresponding to cross sections bounded by the prism and two sets of pinacoids. Some crystals are three inches in length and more than half that in breadth. The green constituent of the rock is reduced to a mimimum occupying the small spaces between. A microscopic examination shows an extreme degree of weathering in some instances, while in other portions the felspars still show twin striations. In the best section (513) the felspars are moderately fresh, so that the extinction angles can be measured without difficulty. The lowest readings are 15° and 18°, and the highest 35° and 37½°, the average of eight being a little over 23°, which indicates felspars running from labradorite to anorthite. The decomposition products observed are zoisite and a very little epidote and quartz. In all the thin sections examined the augitic constituent has completely disappeared, being replaced by very pale serpentine, calcite and epidote.

Anorthosites.

Outcrops of anorthosite occur at several points between the head of Seine bay and the mouth of Seine river. On a hill at the river's mouth a white rock occurs corresponding closely to that described. It is quite badly weathered and the angle of extinction could be determined in only three cases, which averaged 29°, the felspar approaching anorthite more closely than in the Bad Vermilion anorthosite. A comparison of these rocks with the typical anorthosites, so admirably described by Dr. Adams,[58] shows some unimportant differences, due perhaps to the advanced stage of weathering of the Bad Vermilion and Seine bay examples. The felspars do not show the violet color and the innumerable rod-like inclusions mentioned by him; and, so far as the writer has observed, have not the cataclastic structure so common in the anorthosites of eastern Quebec. The felspars appear also to have the porphyritic habit more frequently than in the east. The character of the felspar and its large amount as compared with the darker minerals are points of agreement.

Gabbro and granite.

A difference of opinion between Lawson and Winchell and Grant as to the relative age of these gabbros and the associated granites has already been referred to, Lawson placing the gabbro before the granite in age, and the other gentlemen after. The petrographic examination appears to favor the latter, for the granites have all the characters of rocks that have been

[56]Geol. Sur. Can., p. 99F.

[57]Geol. Nat. Hist. Sur., Minn., Bulletin No. 8, 1893, second Part, p. 7.

[58]Ueber das Norian oder Ober-Laurentian von Canada, Stuttgart, 1893; and the Can. Record of Science, Vol. 6, No. 4.

subjected to strain and fracture, while the anorthosite, so far as the present writer has observed, presents no broken crystals nor undulatory extinction. The occurrence of fissure veins in the granite, as observed by myself and shown by Winchell and Grant, favors the same conclusion.

Serpentines.

As an addendum to the gabbros, the serpentines may be mentioned. Specimens were obtained from Clearwater lake and from lake Despair. A thin section of the first shows only serpentine and magnetite; the latter, which Lawson visited but failed to get good specimens of because of a forest fire,[59] shows in one thin section (550) serpentine, magnetite, a pale mica with interleaved magnetite and remnants of other minerals, taken at first for augite. They have however the properties of tremolite, an angle of extinction running from 15° to 25°, and the hornblende cleavage. As they are dotted with magnetite, they themselves may be a secondary mineral after augite. Two or three remnants having a higher refraction and parallel extinction are no doubt olivine.

DYKE ROCKS.

Basic and acid groups of dyke rocks.

These, the latest rocks of the region, may be divided like the others into an acid group, including granite and pegmatite; and a basic group, including diabase and quartz diabase. Only one example of the acid group will be referred to, a fine grained, flesh colored, somewhat porphyritic granite occurring as a dyke in gray granite or granitoid gneiss at the north end of Sand Point island. Under the microscope it proves to contain quartz, orthoclase, microcline, a little almost invisibly striated plagioclase, probably anorthoclase, a little biotite and muscovite. The same individual of felspar sometimes shows very marked microcline structure at one point, and no trace of it in the rest of the crystal, an occurrence noticed now and then in granites from eastern Ontario. The structure is not sharply cut off, but fades out gently, and suggests a secondary origin, perhaps pressure.

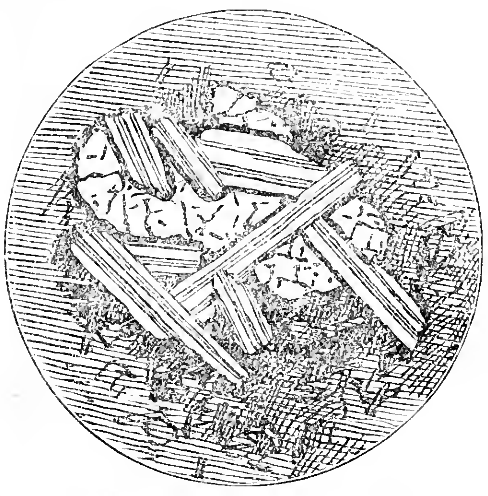

Fig. 16. Porphyritic Aggregate. Swell bay.

A basic specimen described.

Among the basic dyke rocks examined, a specimen from a dyke about a foot wide, running north and south through fine grained granite on location 166T, an island in Swell bay, is the most interesting. The rock is black, very fine grained, and contains small aggregations of pyrite. Under the microscope it proves to be a porphyritic diabase having an ophitic ground mass of plagioclase strips, chlorite, grains of brownish augite and magnetite. The augite is often idiomorphic and twinned, and seems to encroach on the

[59] Geol. Sur. Can. 1887, p. 98 F.

felspar laths. In this magma are imbedded many elongated, idiomorphic felspars, colorless augites with idiomorphic or rounded forms, and more commonly still aggregations of these two minerals. The large augites often have a narrow margin of brownish, similarly oriented material, like the augite of the magma in appearance; and with polarized light they sometimes prove to be twins. In the aggregations we sometimes find a polysomatic mass of augite, but more generally a mixture of elongated plagioclase crystals and augite, the plagioclase having the more pronounced idiomorphism. Portions of the magma may be included in these masses, which are quite irregular in shape, and seldom contain magnetite, a mineral common in the ground mass. It is almost as though fragments of an older, less basic diabase were included in a dark colored later one; but the aggregates are so uniformly distributed and have so small a range as to dimensions as to make it more probable that they are really porphyritic.

Conclusion.

The geologic sequence of events in the region explored.

In following the sequence of events in the geology of the region, we start with a widespread and voluminous deposit of very fine and uniform sands and clayey sands on a sea-bottom far enough from shore action to be free from pebbles, the Couchiching. The origin of the materials for these sediments and the character of the rocky bed on which they were deposited are points on which we have no very definite information, unless certain gneisses on Sand Island river, having alternate layers differing sharply in composition, be looked upon as remnants of an original Laurentian floor.

An era of volcanic activity

After this time of quiet came an era of tremendous volcanic activity, ashes and scoria being rained down, partly perhaps on land, partly on the surface of the sea, to mingle with the beds of waterworn pebbles and boulders along the shore. From time to time there were lava flows, perhaps in widespread sheets like those of more recent geological times in the Western States. The basic lavas were followed by more acid ones, quartz porphyries and their tuffs, until thousands of feet of loose volcanic materials and lava sheets had buried the Couchiching sand beds and the uncovered or only partially covered rock floor to the north.

and rock disturbance.

The thickly blanketed underlying Laurentian rocks became hotter and hotter as ages went by, through the conduction of the earth's central heat outwards; until in spite of the tremendous pressure of overlying miles of strata, they reached a state of semifusion, were set in motion, perhaps by unequal loading; swelled into rounded summits, partially dissolving the overlying schists, floating off and bearing away great masses of them and nipping thick beds of them into sharp synclines in the intervening valleys.

Origin of fissure veins.

Slowly the molten mass cooled, hot water charged with silica and other substances in solution circulated in the innumerable fissures formed by previous convulsions and deposited the veins of quartz and other minerals. Meantime the shattered higher portions of the Huronian rocks, forming the summits of hills or mountains, were eaten away and removed by the action of water, and the surface was at length worn down to a plain; leaving meshes of pinched-in Couchiching and Keewatin rocks surrounding bare areas of gneiss, and here and there disclosing the bosses of granite or anor-

thosite representing the bases of vanished volcanoes. There is no evidence that any rocks later than the Huronian were ever deposited in the region, which has possibly been dry land since that far off time. Certainly if any fossiliferous strata once rested upon the Archaean, erosive forces have completely removed them. The only further point to be noticed is the work of glacial times, when the surface was scoured and furrowed and deposits of loose materials laid down toward the southwestern end of the region.

FLORA OF THE RAINY LAKE REGION.

While our summer's work was specially devoted to studying the gold deposits on the shores of Rainy lake and its tributaries, the plants and animals of the region and its sparse human inhabitants could not fail to attract our attention, and it is proposed to give here a brief sketch of them. Practically the whole of the dry land of the region, where not simply bare rock, either is or was formerly forest covered; and the forests before the action of fire were mainly of coniferous trees, pines and spruces. Three kinds of pine occur in large quantities, the ordinary white pine (*Pinus strobus*), the Norway or red pine (*Pinus resinosa*), and the Banksian or jack pine (*Pinus Banksiana*). The two former trees give the main value to the timber limits of the region, and in voyaging by canoe through the more remote watercourses one still sees here and there fine groves and bunches of these valuable timber trees. As a rule however they are decidedly smaller than the pines once so common in eastern Ontario. The white pine is habitually mixed with other trees, and on this account is more readily injured by fires, which rapidly spread by reason of the dead leaves and underbrush at dry seasons of the year. The somewhat less valuable red or Norway pine occurs in much larger quantities than the stately white pine, and commonly forms groves which more or less completely exclude other trees. These groves of tall red trunks with their crown of dark green showing distinctly along the hills, with little or no underbrush, are very impressive to look upon. The red pine, partly no doubt from the absence of undergrowth, withstands fire better than any other tree in the region. There is little material at the base in which the fire can run, and the thick, non-conducting bark of the trunks prevents fatal injury if the fire sweeping through is not too fierce. In woods of mixed timber it is a surprise to see splendid red pines left apparently uninjured after the surrounding trees have been burnt to a crisp and ruined. The red pine seems to grow to fair dimensions on a minimum of soil, often apparently rooting itself in the fissures of the bare rock. The jack pine never reaches the size of the other two species of the genus, and is usually too scrubby for use, though many trees would furnish railway ties if they were in demand for this purpose. As long however as better timber is available it seems as if this tree would remain untouched. It is no doubt the most generally diffused pine of the region.

Coniferous trees.

White, red and Banksian pines.

Of other coniferous trees, the deciduous tamarack (*Larix Americana*) occurs sometimes in swampy tracts, but the spruces are very much more common, forming monotonous woods often of uselessly small trees along many miles of the muskeg borders of the sluggish streams. Cedar is seen comparatively rarely, and not often of such dimensions as to be of value.

Tamarack and spruce.

Deciduous trees: poplar, birch, elm, oak, maple and ash.

Deciduous trees of little value, chiefly poplar and birch, are very widespread, especially where fires have run; these trees commonly forming the second growth, their seeds having more efficient means of dispersion than the rather heavy and only slightly winged seeds of the conifers. Along some of the rivers, elms give a pleasant variety, and oaks, maples and ashes are also found, though more rarely.

Shrubs and flowers.

There are of course many woody plants of lower growth, giving a dense underbush in many places, and including berry-bearing shrubs, such as the blueberry and cranberry. The minor flowering plants it would be unwise to attempt to enumerate. The traveller by canoe cannot fail to be attracted by the magnificent white water lilies along the more sluggish streams, where the moose has not worked destruction by tearing up their roots from the mud to feed upon them. Yellow water lilies are numerous of course, and there are dwarf species of both colors with tiny flowers a half inch in diameter in some parts of the watercourses. In the wide swamps along the shores of muddy lakes and rivers the wild rice thrives on the muddy bottom, though it is much more abundant to the north near lake Wabigoon than in the neighborhood of Rainy lake. A most interesting find was a tiny patch of cactus on Red Pine island, in Rainy lake. The plants are small and very prickly, and appear to grow only in a spot of lichen-covered rock a rod square on the island mentioned, since our halfbreeds, who knew of its presence there, had no knowledge of its being found elsewhere. Dr. Macoun has determined a specimen to be Opuntia fragilis, and states that a few specimens of the same species were found by Dr. Lawson ten years before on an island in the Lake of the Woods.[60] These are the only known localities where the cactus grows wild in Ontario.

Rice.

Cactus.

Forest fires, and their terrible ravages.

The flora of the region includes beside the two timber producing pines conparatively few plants of much economic value, though the berries and the wild rice afford a harvest of some importance to the Indians. But little pine has been cut during the last two or three years, on account of the depression in the building trade; but probably a considerable amount has been cut during the past winter, for the sad reason that the trees have been killed by fire and if not put into the water within a year or two will be rendered worthless by the borers. If the spread of forest fires is not prevented the time is not far distant when the pine of the Rainy Lake region will be at an end. The fury of these fires is not conceived by the dweller in the cleared and settled east. The present writer found himself last August in the range of a terrible fire which swept over hundreds of square miles of territory in the neighborhood of the Atik-okan river and the chain of lakes between it and and Lac des Milles Lacs. So dense was the smoke that on even narrow lakes the canoe had to be steered by compass, unless one were content to coast slowly along the shore. On Baril lake, August 29th, the air was so thick with smoke and falling ashes and cinders that it became dark at noon day, and we simply had to land and wait on the blackened, fire-ravaged shore till the worst of the gloom had been washed out of the air by a shower. The flare of blazing trees at night in the half choking atmosphere made one very

[60] See Canadian Record of Science, vol. vi, No. 4, 1895, p. 201.

careful to camp where the fire had already passed, leaving nothing more to burn. So furious was the conflagration that birds were killed in the air, and in the case of one small lake all the fish perished, and floated dead on the surface when we passed a day or two later. Large trees are not burned completely by these fires, as a rule, but are generally killed, and in a very short time the blackened trunks are invaded by the larvæ of *Monohammus confusor* or *M. Sentellatus*, which tunnel into the wood and destroy it. The ceaseless sound of their rasping horny jaws can be heard at times for a quarter of a mile away from these shadeless, funereal forests, and little heaps of sawdust soon accumulate at the foot of each tree.

THE FAUNA.

The Rainy Lake region seems one of the favorite haunts of the moose, the largest of American mammals since the practical extinction of the buffalo, and many of them are killed for food every year, the flesh of one in good condition being unsurpassed. If the Indians are to be trusted, they are increasing in numbers. The caribou too is common in some parts, but the red deer is very rare; in fact our halfbreeds informed us that the red deer were unknown until five years ago, but that now they are gradually coming into the country. With the red deer doubtless will come their inveterate enemies, the wolves, so rare at present that we neither saw nor heard one during the summer. Black bears are not infrequent, and the smaller fur-bearing animals provide a large part of of the Indian's income. All the ordinary wild fowl of Canada are numerous, and no more delicious ducks can be found than those that have fattened on the wild rice of the Wabigoon. Gulls frequent the larger lakes, and loons rouse the echoes on the smaller ones with their mournful cry. Fish are abundant, though not always of the best. Whitefish are caught in the larger lakes, trout in the clearer ones, and black bass in only one lake out of the thousands. Tormenting insects are numerous and venomous in their season, almost the worst being the dogfly, an innocent looking insect like a housefly, but smaller, which reduces the ears of the Indian dogs to a mass of raw flesh. The dragonfly here as elsewhere cruises in the dusk for its favorite food, the mosquito.

Moose, caribou and red deer.

Bear and wild fowl.

Fish.

Insects.

THE INDIANS.

The Indians of Rainy lake speak the Ojibeway language, and are scattered as small bands on reservations here and there through the region. They are reputed to be pagans as a rule, though the Church of England and the Roman Catholic Church have each a few adherents among them. Although provided with reservations on which a certain amount of land has been cleared and small log houses built, they appear to do very little in the way of farming, and depend for a livelihood mainly on fishing, trapping and hunting, the proceeds being eked out by the sale of blueberries, which they ship to Rat Portage; and by gathering a few bushels of rice, of whose long black grains they are very fond. On each reserve they have a small herd of cattle. Their most important manufacture is the bark canoe, for which they find a ready sale at present to explorers. The Rainy lake canoes are only moderately good, since the birch bark to be found in the region is from comparatively small trees. That they have some artistic taste is shown in their stone pipes, which are sometimes elaborately and prettily carved.

Indians of the Rainy Lake reserves,

and their characteristics.

As canoemen and pioneers many of the halfbreeds from the settlement near Fort Frances are very efficient, and a few of them, who have had training under Hudson Bay officials, are good camp cooks. Both halfbreeds and Indians are keen observers, and several gold locations have been taken up on information given by them. They are beginning now to know the value of gold and to join prospecting parties, but their greatest drawback is their want of knowledge of English, which however they will doubtless pick up with many less desirable accomplishments as white men pour into the country. Many of them have a dangerous craving for liquor, which they can now satisfy by crossing the line to Rainy Lake City or Koochiching; but away from such temptation they seem to be harmless and peaceable. What effect the sudden influx of hundreds or thousands of adventurous white men will have upon these isolated and ignorant communities of half civilized Indians remains to be seen; but it is to be feared that their morals at least will hardly be changed for the better. It is doubtful if the policy of placing them on small scattered reservations with only a few scores of inhabitants in each is a wise one under present circumstances. On a single large reserve they could have much more efficient oversight and protection from the sale of liquor; and the children, who are now only nominally educated, and in many cases not at all, could be gathered into good schools.

Gold discoveries on the reservations.

If discoveries of gold are made on these reservations, and there is every probability that this will occur, there will be a demand for some re-arrangement of present conditions by which these lands, now locked up from the enterprise of white men, may be developed as their resources demand. The chief of one of the reservations, having found what he believed to be a gold bearing vein on his land, enquired of the writer how he could dispose of it, since he and his tribe wanted the money it would bring. At present of course these wards of the Crown can transact no such business except through the somewhat slowly revolving machinery of the Indian Department; and he was informed that nothing could be done except through the agent in charge of the Rainy Lake reservations.

THE McGOWN MINE IN FOLEY.

Location of the property.

Early in October a visit was made to a new and very interesting gold deposit, the property of Thomas McGown and Sons, Parry Sound. The deposit is situated just north of the Parry Sound-Rosseau colonization road, two or three miles east of the former town. The gold occurs in a bedded vein, or rather a series of parallel veins and stringers, having a width of about 3 feet and extending about 100 feet, so far as exposed by stripping. Beyond these limits it has not been traced with certainty. The vein has a strike of 70° west, parallel to the enclosing rocks, and dips 40° to 50° to the south. The gold occurs as small nuggets and scales in vitreous quartz associated with copper sulphides, chalcocite or copper glance, bornite or peacock ore, a little copper pyrites, and their decomposition products, oxides of iron and malachite. The chalcocite and bornite are mixed, and sometimes form quite large lumps. The gold may be found in the quartz, in the sulphides, and between the two.

Occurrence of the gold.

An assay of the bornite gave $4 per ton of gold. No iron pyrites was observed. It is probable that on sinking on this vein the sulphides will change to copper pyrites.

The vein rock

As vein rock there is, besides quartz and portions of intermixed wall rock, a curious brownish, fine grained material consisting of quartz, confusedly disposed muscovite, and brown and red garnet, the latter often enclosing patches of green epidote, no doubt a decomposition mineral. There is also a little titanite of almost the same color as the garnet.

and the country rock.

The country rock in which the vein occurs consists of a speckled gray, slightly schistose rock resembling diorite, or diorite schist. On examining thin sections one finds that part of it at least is a gabbro of somewhat unusual habit, made up of about equal amounts of plagioclase, augite and hornblende, with biotite, apatite and sulphides as accessories. The plagioclase has not the ophitic shape, is in general clear and unweathered, but has its twin planes bent. The twinning is after the two usual laws, having angles of extinction corresponding generally to labradorite, though angles as low as 10° were observed. At the edges of some felspars an appearance very like micropegmatite is sometimes seen, but no quartz beside this is to be found. Part of the augite is green, not pleochroic, has a high angle of extinction, and sometimes contains parallel platelike inclusions, but beyond this has not the look of diallage. Another part of the augite, probably hypersthene, is quite strongly dichroic (pale red and green), contains no inclusions, and in some cases has parallel extinction ; but in others must be rotated about 5° from the predominant cleavage before extinction takes place. The two minerals are much alike in cleavage and general appearance, and often have a thin margin of green hornblende. The hornblende, which is compact, green and strongly pleochroic, is probably of secondary origin ; and the same is true of the brown biotite. The apatite forms thick prisms.

Minerals of the neighborhood,

In the neighborhood we find thick dykes of pegmatite intersecting the gray schistose rocks ; and a mile or two to the west, within the limits of the town, greatly contorted gray schists and gneisses of totally different appearance are found, having the *augen* structure very strongly marked. The augen, which are sometimes two or three inches in longest diameter, are almost pure white, and generally show an oval individual of striated felspar, surrounded by a granular layer, no doubt of the same mineral crushed. Occasionally a large crystal of black hornblende occupies a similar position. A thin section of the gray rock proves to contain quartz, othoclase, perfectly clear and white, but with cleavages distinguishing it from the quartz, a little plagioclase, with very low angles of extinction, and hornblende. A little biotite, a number of pale garnets and a very few zircons complete the list.

Near the harbor exceedingly coarse grained pegmatite veins cut through the schistose rocks, their felspars sometimes showing cleavage planes two feet in length. The " graphic " arrangement of quartz and orthoclase is not uncommon in these dykes.

and at Parry Sound.

Just at the limit of the corporation a bed of coarsely crystalline, flesh colored limestone is exposed near the roadside. It contains a good deal of biotite in bands, and also many contorted and broken fragments of gneiss, as

though it was an eruptive rock. No doubt during the folding of the tougher schists the limestone has been squeezed, as the more yielding material, into openings, probably at synclines and anticlines, and has swept with it some fragments of gneiss. The general character of the rocks in the neighborhood of Parry Sound, so far as observed during two stormy days of October, suggests the Grenville series, or Upper Laurentian; but the region would repay a careful study in detail.

rious copr ore.

Up to the present the McGown gold deposit, with its interesting and unusual association of minerals, stands alone, since gold has not been found elsewhere in the district. A curious copper ore has been obtained however some miles south of Parry Sound; a mixture of copper pyrites, iron pyrites, zincblende and garnet; but this has not proved to be auriferous.

SECTION III.

· THE HINTERLAND OF ONTARIO.

The province of Ontario occupies a unique geographical position, a position which confers upon her singular advantages for purposes of trade and commerce. To the south of her lies the magnificent chain of lakes which contains about one-half the fresh water on the globe, and the remarkable fact is that the entire northern coast-line of these inland seas—lake Michigan, which is wholly within the United States, excepted—is formed by Ontario territory. Even beyond the vast basin of lake Superior her southern limit extends until it strikes the province of Manitoba at a point midway between the Pacific and the Atlantic oceans. The international line dividing Canada from the United States runs through the middle of the lakes, and faces the northern boundary of New York, a small part of Pennsylvania, two-thirds of Ohio, the whole of Michigan and Wisconsin and nearly the whole of Minnesota, and yet confronts the territory of Ontario all the way. Her southwestern peninsula, surrounded almost on all sides by the commerce-inviting waters of these lakes, cleaves the very heart of the great republic, and brings her people and her products into touch with the largest cities, the richest areas and one-half the population of the United States. Her eastern corner is but a few miles above ocean communication at Montreal. Her rivers run east into the St. Lawrence, south into the great lakes, west into lake Winnipeg and north into Hudson bay. No immense mountain ranges divide one portion of the province from another, or render railway building in any direction an impossible or difficult task, or make her streams and rivers subject to the dangers of overflowing at flood time. Her climate varies from the warmth and geniality of the lake Erie counties and the Niagara peninsula to the sub-arctic rigor of the country inland from lake Superior; while the fertility of her soil, the wealth of her natural resources and the extent of her territory are such as to give her a commanding place not only among the provinces of the Dominion, but also among the commonwealths of the continent.

Geographical position of the province.

The Hinterland Territory.

The area of Ontario is estimated to be 126,000,000 acres, or approximately 200,000 square miles. About 60,000 square miles of this lie south of the French river, lake Nipissing and the river Mattawa, and until a very recent date comprised all that was thought of as forming Ontario or Upper Canada, as it used to be called, and a very large extent of country besides. South of this line are situated the bulk of the population, the cities and towns, a large proportion of the arable lands, the manufacturing industries, the schools and colleges; in a word the greater part of the civilization of the province. North of it, at the back of the cultivated and settled districts, stretches the

Extent of the province,

and of the Hinterland.

Hinterland of Ontario, a vast region reaching from lakes Huron and Superior on the south to the Albany river and James bay on the north, which has for its eastern limit the boundary line between Quebec and Ontario, and for its western limit Rainy river and Lake of the Woods. This whole territory contains an area of about 140,000 square miles, of which perhaps 80,000 square miles lie on the Hudson Bay slope north of the height of land. This height of land is the watershed which divides the streams flowing into the Atlantic ocean through the St. Lawrence from those emptying into Hudson bay. Its course is extremely irregular, but may be described as follows: Beginning at a point on the eastern boundary of the province near Labyrinth lake, which lies between lakes Temiscaming and Abittibi, in latitude 48° 15′ north, it follows a southwesterly direction past the great bend of the Montreal river until within 50 or 60 miles of the north shore of Georgian bay, whence and approximately at this distance it continues parallel to the coast and the east and north shores of lake Superior, until north of Michipicoten island it makes a great deflection to the southwest. Passing round the southern end of Long lake it approaches within 20 miles of lake Superior at a point north of the Slate islands; thence turning to the north and west it makes a bold curve around the head of lake Nepigon at a distance of 20 miles; and passing 50 miles west of that lake and lake Superior in a southwesterly direction it crosses the international boundary between the province of Ontario and the state of Minnesota at the source of the Pigeon river. The height of land is not a range of mountains, nor even a ridge of hills. It is rather an upland or plateau of varying width, but of remarkably uniform height, varying from 1,200 to 1,500 feet above the level of the sea. The whole region under consideration indeed, viewed on the large scale is extremely level, and the scenery though diversified by hundreds of rivers and streams, thousands of lakes and innumerable crags and hills of rock, is certainly lacking in that nobility and largeness of view which only the presence of lofty mountains can bestow.

Position of the height of land,

and its effects on the topography of the country.

A glance at the map will show that the position of the dividing ridge is attended with important consequences to the topography of the country. The rivers which flow southward into the great lakes are much shorter and of smaller volume than those which run northward into Hudson bay. The Kaministiquia, the Nepigon and the Michipicoten are the only important streams falling into lake Superior on its northern side. The Mississaga, the Spanish, the Wahnapitae and the French (which forms the outlet of lake Nipissing) are the largest tributaries of lake Huron, whose feeders are on a grander scale than those of lake Superior.

One may notice in passing the smallness of the drainage areas of lakes Superior and Huron as compared with the immense size of these bodies of water. This peculiarity, it seems probable, may have some influence in causing the fluctuations noted in the level of these lakes. Coupled with the rocky, unretentive character of the soil, which provides a minimum of capacity for absorbing moisture, and the scarcity of important lakes to act as feeders, the smallness of the basin renders it likely that the successive falls of rain and snow are carried away during the season in which they are precipitated. In this way an unusually dry or wet year would take immediate

effect upon the level of the lakes, there being but little ground for the water to traverse and very few great settling basins in the shape of large lakes to retard and equalize its flow.

The north bound streams on the other hand, though less known to fame, much surpass in size those flowing south. The principal of these are the Albany, which has a length of about 475 miles, its branches the Ogoké and Kenogami, the Missinaibi or North Moose, the Mattagami or South Moose, 270 miles long, and the Abittibi, 216 miles. All these are large rivers with numerous tributaries. During the season of high water shallow draft steamers might ascend the Moose and two of its branches for upwards of 100 miles and the Albany for 250 miles, or as far as Martin's Falls. The Rainy river, which rises not far from the western shore of lake Superior and empties into Lake of the Woods, and so finally into Hudson bay, is navigable from Lake of the Woods to Fort Frances, near Rainy lake, and is really a part of the northern water system ; while the Montreal and Blanche, which run southeasterly into lake Temiscaming, belong to the southern system.

THE SOUTHERN SLOPE.

Opened up by the Canadian Pacific Railway.

The country south of the height of land, though by no means well known, is yet more familiar to the people of older Ontario than the Hudson bay slope. The building of the Canadian Pacific Railway, whatever else it may have done or entailed, has certainly been of great benefit to this province in affording means of access to a large portion of the public domain which would otherwise be still as inaccessible as the district north of the height of land. The general impression is that this whole tract of land lying north of lakes Huron and Superior traversed by the railway is a barren and inhospitable wilderness. Minerals have been discovered at certain points and the lumber industry certainly thrives, but as for ever supporting an agricultural population on these ridges of granite, the idea is preposterous. And yet preposterous as it is, the thing is being done. It is being found out that the country is more forbidding in appearance than in reality. The rocky bluffs in many places hem in fertile flats, and in the valleys of the numerous streams and rivers there are many tracts of first-rate land of considerable extent. The railway gives easy access, and the lumbering industry affords a steady market for all agricultural products. On lake Temiscaming, round Mattawa, North Bay, Sturgeon Falls, Sudbury, Chelmsford, Webbwood, Massey Station, Thessalon, Bruce Mines, Sault Ste. Marie and Goulais bay, as well as on Manitoulin and St. Joseph islands, there are thriving settlements, and in some places farms which would not disgrace the older parts of the province. The north shore of lake Superior is not as yet much affected by settlers, and probably contains but little good land. But in the townships around Port Arthur there is a considerable farming population ; while in the fertile, well-timbered valley of the Rainy river there is room for thousands.

The lumbering industry.

The chief industry of the district is lumbering, which is carried on with greater or less activity, according to the state of trade, on almost all of the rivers running into lake Huron and the Ottawa. The only timber that is cut for purposes of lumber is the pine, but of late years a growing business

has been done in timber suitable for the manufacture of paper, or as it is called, pulpwood. The tree that is most in demand for this purpose is the spruce, which is cut into four-foot lengths and floated down stream to be loaded into barges and taken to the United States, where the work of manufacture is carried on. There are no paper mills on the Ontario side, though one would imagine the nearness to the source of supply would be a great advantage. It is understood that this want may in part be soon supplied. Great rafts of saw logs are every year towed across Georgian bay and lake Huron to be manufactured into lumber by American mills. The recent change in the United States tariff by which lumber is admitted free is however having the effect of transferring a considerable proportion of this industry to the Ontario side.

Farm products.

The principal farm products in all the region south of the height of land are hay, oats and potatoes, for the growing of which the land is well adapted, and which all find a ready market in the lumbering camps at higher prices than can be had in the older parts of the province. Indeed there is not enough hay and oats raised in the district to supply the local demand, and quantities are regularly brought in every year to make good the deficiency. Peas are largely grown, and are found to be free from the bug which infests the crop in other parts of the province. Little or no wheat is sown, as the district is almost universally supplied with Manitoba flour.

THE NORTHERN SLOPE.

Backbone of the continent.

Ontario, south of James bay, is interesting from a geological point of view, as most of it lies within that great Archæan area which was the first part of North America to rise above the waters of the primordial seas. This nucleus or backbone upon which the remainder of the continent has been built up has been described as extending from the region of the great lakes in the form of two arms, one stretching eastward to the Atlantic coast and the other northwestward to the Arctic sea east of the mouth of the Mackenzie river. Its full outline is probably in the shape of an ellipse, including on the east Baffinland, Greenland and many of the islands of the frozen sea, and on the west stretching from lake Winnipeg to Coronation gulf, with a spur towards the mouth of the Mackenzie river. The palæozoic rocks of Hudson bay form a sort of broken fringe around that inland sea, and a belt of them extends thence northward across some of the islands to the Arctic ocean. The geographical depression of Hudson bay, to which the rivers flow from all sides, forms the central drainage basin of the azoic area of North America, and its origin is of very ancient geological date. Taken as a whole, northern Ontario is probably largely Laurentian in geological character, though extensive areas of Huronian strata also occur. The great Huronian belt lying to the north and northeast of lake Huron and reaching from the east end of lake Superior to the line between Ontario and Quebec (where it is 100 miles wide) and far into the latter province, is perhaps the largest of these areas.

Laurentian and Huronian areas.

Palæozoic rocks of the north.

The palæozoic and tertiary basin of James bay is quite distinct in its general features from the Laurentian and Huronian plateau to the south. The latter is elevated, undulating, and dotted with hundreds of thousands of

lakes, containing in the aggregate an enormous quantity of fresh water, while the former is low, level and swampy, and as far as known generally free from lakes. The southern edge or rim of this basin is formed by the hard, ancient rocks composing the base of the height of land. Owing to the unyielding nature of these rocks, all the rivers running into James bay meet with a great and very rapid descent on reaching the edge of this basin. As a consequence the long portages on the Abittibi, the Mattagami, the Missinaibi and the Albany are all to be found where they pour their waters down this slope a short distance southward of the margin of the palæozoic rocks. In ten miles the Missinaibi falls nearly three hundred feet, and the Mattagami not less than four hundred and twenty-five feet in a like distance.

AN UNEXPLORED REGION.

The unknown interior.

As has been already said, the region north of the height of land, and to a considerable extent south of it, has been very partially explored. Some portions of it have never yet been trodden by the foot of the white adventurer. There are rivers many miles in length, whose existence is known, but whose courses remain only as dotted lines on the map. The sole means of travelling is the canoe, and hence only the country in the immediate vicinity of the rivers has yet been described from ocular observation; for a journey from the great lakes to James bay is both difficult and uncertain, and little or no attempt has been made to penetrate far into the interior away from the water highways. Dr. Robert Bell of the Dominion Geological Survey and Mr. E. B. Borron, stipendiary magistrate for the district of Nipissing, are perhaps the only two scientific observers who have made systematic examination of the region on an extended scale, and it is to these two intrepid explorers that we owe a very large part of the information we possess concerning it. Dr. Bell has conducted a number of expeditions to Hudson and James bays by various routes, and has made a study of the geology and resources of the district. Mr. Borron, as an officer of the Government of the province and an old miner, has contributed a good deal to our scanty stock of knowledge concerning its minerals. The engineers of the Canadian Pacific Railway in the early days of that undertaking, explored a considerable tract of the country from east to west across the several branches of the Moose river, and their reports are valuable as constituting the chief source of information respecting the character of a considerable part of the region inland from the waterways both north and south of the height of land. A short description of the district between North Bay and lake Temiscaming is given in the report of the Commission on the Mineral Resources of Ontario by Mr. J. C. Bailey, who explored it in 1889 in the interest of the Nipissing and James Bay Railway, of which he was engineer. This section is, however, comparatively well known, a colonization road 83 miles long having been built by the Department of Crown Lands between these points and finished in 1888 at a total cost of $13,800.

Sources of information respecting it.

Climate of the Hinterland.

Comparative latitudes.

The territory under treatment extends from latitude 46° 30′ to 52° north, a distance of about 400 miles. What is its climate? The whole of Ireland and Scotland, and nearly the whole of England lie farther north than the most northerly point of this territory; so do Denmark, Norway and Sweden, large portions of Germany and the Russian possessions in both Europe and Asia. Part of this great lone land extends a considerable distance south of the latitude of the international boundary between Canada and the United States, and is in the same zone as France, Switzerland and Austria; the central portions are in the same latitude as Manitoba and the settled part of British Columbia; while the whole of it is south not only of the ranches of the Peace river, but also of the wheat-growing lands of the Saskatchewan. A large portion of the territory lies farther south than the gulf of St. Lawrence, and a considerable part in the latitude of New Brunswick and the state of Maine. But mere latitude does not make a climate, and it is evident that the tempering influence which the gulf stream exercises on the British isles, for instance, is wanting here. Instead we have the vast expanse of Hudson bay, opening on the north into the Arctic ocean and exposed to the influence of the icy currents which flow southward from the frozen regions of the pole. The lowering effect of Hudson bay on the climate of the territory to the west and south must be considerable, but it is doubtful whether on the whole it is not largely counteracted so far as those parts of Ontario contiguous to James bay are concerned by various circumstances of an ameliorating kind. The question of altitude has quite as great a bearing on climate as that of latitude, and in this respect northern Ontario possesses a decided advantage, for, as has been said, no part of it rises more than 1,200 or 1,500 feet above sea level.

Causes which influence the climate.

Ocean currents.

"The climate," says Dr. Bell, "in going northward from the height of land towards James bay does not appear to get worse, but rather better. This may be due to the constant diminution of the elevation more than counterbalancing for the increasing latitude, since in these northern regions a change in altitude affects the climate much more than the same amount of change would affect it in places further south. The water of James bay may also exert a favorable influence, the bulk of it being made up, in the summer time of warm river water which accumulates in the head of the bay and pushes the cold sea water farther north. The greater proportion of day to night during the summer months may be another cause of the comparative warmth of this region."[1]

Altitude.

Length of day in summer.

Mr. Borron states that "the climate of this territory in respect of temperature is one of extremes. The winters are cold—the temperature falling sometimes as low as 40° below zero of Fahrenheit's thermometer, and occasionally rising to 90° in the summer even down on the coast. Last year (1881) it was on one occasion 94° in the shade at Albany Factory and 92° at Moose Factory. The mean temperature at Moose Factory of the summer is about 60°."[2]

A temperature of extremes.

[1] Geological Survey Report, 1875-76, p. 341.

[2] Report on Basin of Moose River and Adjacent Country, 1890, p. 24.

In 1880 the mean average temperature at Moose Factory was: May 40°, June 55°, July 59°, August 55°, September 52°, October 38°. In his exploration of the east coast of Hudson bay in 1877 Dr. Bell says he took the temperature of the sea upwards of 20 times during July, August and September, and found it to average 53° Fahr. The average of the water in five of the rivers was 61°. In the same year the doctor states that at Moose Factory in the end of September he found there had been no frost all summer, and the most tender plants such as melons and cucumbers, beans, balsams, tobacco, the castor oil bean, etc., growing in the open air, were still quite green and flourishing. The summer of 1877 was however, Mr. Borron remarks, probably a finer one than usual. The rain fall at Moose Factory in 1878 was 26.86 inches.

Records of temperature by Dr. Bell.

The Hudson's Bay Company's officials raise potatoes and other vegetables in abundance at Moose Factory, as well as barley, which ripens, though not every year, and upwards of eighty head of cattle are kept there, besides horses, sheep and pigs. At the mouth of the Albany, about 100 miles north from Moose Factory, the soil and climate are not much different, and the marshes on the coast furnish abundant food for cattle. Potatoes yield bountifully in almost every part of the territory where they have been tried. The Colorado potato bugs had not reached Moose Factory at last accounts, but were numerous at Lake Temiscaming, and had got as far north as the height of land. Barley, oats and wheat are also grown with greater or less success at various H. B. posts, and all the ordinary garden vegetables are cultivated without difficulty.

Farm products at H. B. Co.'s posts.

In the less remote districts the climate is well known. It cannot be denied that the winter is severe and long, measured by the standard of Toronto. But wherever settlement has taken place there is found to be ample time in the spring, summer and autumn months for the growth and ripening of crops, and no complaint is made that farming operations are materially retarded by climatic conditions. This applies to the settlements on the Rainy river and along the main line of the Canadian Pacific Railway, as well as to those north of lake Huron and at lake Temiscaming. Mr. C. C. Farr, a long resident at the latter place, says that while it would be misleading to say there are no summer frosts in that district, yet anything that can be grown in a temperate climate can be grown there, and in his list of vegetables, cereals and fruits he enumerates such tender plants as beans, melons, tomatoes, cucumbers and tobacco. Seeding time, he says, commences about the first week in May, haying about the 14th of July, and harvest the 15th of August. The fall is open, and the large lake seldom frozen before the second week in December. From these facts it is evident that the climate of the Hinterland is far from being a hyperborean, or even a frigid one. It is the climate of older Ontario, somewhat intensified in winter.

Climate of the less remote districts favorable for farm crops.

Land Available For Agriculture.

Dr. Bell's testimony.

The proportion of land available for agricultural purposes is difficult to estimate. Dr. Bell says: "Loose materials of some kind actually cover the greater proportion of the area, and in a very considerable percentage of it the soil is more or less suited to agriculture. In a general way there is perhaps a greater proportion of good soil in the plateau region northward than southward of the height of land."[3] Again the same gentleman remarks: "The country immediately surrounding Hudson bay cannot be said to be an agricultural region, but to the southward of James bay, the southern prolongation of Hudson bay and to the southwestward, there is a long tract of land which sooner or later will be, I believe, of value for agricultural purposes. It extends for a distance of nearly 200 miles in a southerly and southwesterly direction. The immediate shore of James bay, towards the south end, and the country for some distance back, is covered with sphagnum moss, but this does not exist far inland. The greatest extent is between the lower parts of the Albany and Moose rivers, but beyond that there is a level tract of excellent land, well wooded, and southward and southwestward of that again the country rises pretty rapidly for a short distance and we come upon a plateau which extends inland for another 100 miles, and over the greater part of that the land is excellent as far as I could judge. I have surveyed all the principal rivers and lakes and canoe routes of that country, and made excursions inland to see the rocks and the soil, and it would be what we should consider in western Canada good land."[4]

The C. P. R. Eastern or Woodland District.

It will be remembered that the Canadian Pacific Railway as at first projected took a much more northerly route from Mattawa to Winnipeg than that which was actually adopted. This portion of the line constituted the Eastern or Woodland division of Sandford Fleming and the early engineers, and as the region which it traversed was then even less known than it is now, it was deemed expedient to put a number of surveying parties in the field to examine the country and lay down the most practicable route for the railway which the admission of British Columbia into Confederation made it necessary to construct. This exploratory survey began in June, 1871, and the work undertaken, covering as it did an extent of about one thousand miles through a trackless wilderness, far from supplies and means of communication, was one of unusual difficulty. The reports of the various parties made from time to time as they succeeded in accomplishing the task set before them contain a good deal of valuable information. The prime object was, of course, to find a suitable railway line, but the character of the country, its suitability for agriculture, and its resources of timber and minerals were hardly less important, as indicating the sources from which the future railway would derive business and revenue. A map of part of the Dominion of Canada issued by the Department of Crown Lands in 1877 shows the Canadian Pacific line as

Evidence of the C. P. R. exploratory survey.

[3]Report of the Geological Survey of Canada, 1875-76, pp. 339, 340.

[4]Evidence before Immigration and Colonization Committee, House of Commons, 1883, Dom. Sess. Papers, 1883, Appendix No. 6, p. 52.

then located to run from Mattawa up the Ottawa river to the junction of the Montreal river with lake Temiscaming, thence up the valley of the Montreal to the great bend of that river, thence crossing the various branches of the Moose to the southern end of lake Kabinakagami. From this point two alternative routes are shown, one running north of lake Nepigon, the other trending towards lake Superior and south of lake Nepigon, but both converging after leaving the latter body of water, passing south of Lac Seul (Lonely lake) and north of Lake of the Woods, and uniting at a point on the Winnipeg river some distance east of Winnipeg, or, as it was then called, Fort Garry. In describing the country through which this trial line was run Mr. Fleming says:

Sandford Fleming's description.

"Compared with the country on the Pacific coast no part of this region can be considered mountainous. Along the shores of lakes Superior and Huron a considerable extent of rough and broken elevated ground is found, but the maximum elevation attained in the highest portion of this woodland region will not exceed 2,000 feet above sea level. The band of rocky hills which runs along lake Superior is variable in width, ranging from forty to seventy miles, and its eastern extension assumes on the north side of lake Huron a width of about fifty miles. Behind the rocky elevated range referred to the surface is found to be comparatively flat. Between the province of Manitoba and lake Superior the drainage of the country is mainly westward, passing into lake Winnipeg. The water shed between the two lakes is quite close to lake Superior and maintains a nearly uniform elevation of from 1,400 to 1,500 feet, while lake Superior is 600 feet and lake Winnipeg 710 feet, above the sea. The descent from the watershed westward is very gradual, and the country for the whole distance is remarkable for the innumerable streams and lakes with which it is intersected. These consist of long, winding sheets of water, separated by rocky ridges; and so numerous are they that an Indian in his canoe can travel in almost any required direction by making an occasional portage. Lake Nepigon lies directly north of lake Superior, and discharges into it by the river Nepigon. The descent to the latter lake is 252 feet. Lake Nepigon is the most northerly reservoir of the St. Lawrence basin, the brim of which is here extended 120 miles north of lake Superior. The outline of the watershed is however so irregular that a few miles to the east of lake Nepigon the brim of the basin curves round until it reaches a point within 20 miles of lake Superior North of this point the waters flow towards Hudson bay. Although the general aspect of the country east of lake Nepigon as seen from lakes Superior and Huron is precipitous and rugged, to the rear of this wild and rocky frontier the surface descends northerly in easy slopes. So much is this found to be the case, that in passing from lake Nipissing to lake Nepigon, through the interior of the country, the ascent to the summit level will actually be less than that which is experienced in passing from Toronto across the peninsula of western Ontario by either the Great Western, the Grand Trunk, the Grey and Bruce, or Northern railways. The drainage of the flat country referred to as existing between the Nepigon basin and the Ottawa valley flows northerly by the rivers Albany and Moose to James bay; while the drainage of the rugged,

elevated belt along lakes Superior and Huron passes into the basin of the St. Lawrence. The agricultural resources of this extensive region of country are not promising. But the timber which covers its surface will every year become more and more valuable, and its geological structure affords indications of mineral wealth."[5]

Engineeer Rowan's report.

Mr. James H. Rowan, C.E., was in charge of the surveys in the Woodland division, and in reporting to Mr. Fleming under date of 5th June, 1873, on the success which had attended the efforts to locate a line of railway from the vicinity of lake Nipissing to Red river, on which neither the amount of excavation and embankment, the bridging, the grading or the curves would be exceptionally heavy, he remarks as to the general character of the country :

" Attention to the particular work on which they were engaged left little time for other explorations at the disposal of the various parties. It may be stated however that the country traversed gave indications, at many points, of the existence of iron, copper, gypsum, also of the more precious metals ; and I think it is not improbable that coal or other mineral fuel may be found, if not immediately on the line of railway, probably at no great distance from it in the country to the north. Sufficient timber for railway purposes can also be procured, and although a considerable portion of the land may be unfit for agricultural purposes, there are tracts of fair quality to be met with at various points along the line."[6]

Elevations.

A list of elevations above the sea of the principal lakes and rivers on the line is appended to Mr. Rowan's report, from which it appears that Sturgeon lake, west of lake Nepigon, is the highest point on the route, being 1,327 feet above sea level. It would seem therefore that Mr. Fleming put the figure too high when he estimated that the greatest elevation on the line north of lakes Superior and Huron might reach 2,000 feet above the sea.

SOME DETAILS OF THE WOODLAND DISTRICT.

From Rat Portage to the height of land.

Speaking of the Woodland division in detail, Mr. Rowan remarks that from Rat Portage east to the height of land, a distance of 230 miles, there is a rise in elevation of between 400 and 500 feet. A striking peculiarity of the country is the great extent of water surface, consisting of lakes and lacustrine streams of every conceivable shape and size, the former for the most part lying in the direction of the rocks, the latter occasionally cutting across it. The hills which almost universally follow a general direction from northeast to southwest consist chiefly of Laurentian rocks. Mr. Rowan noted evident indications of the whole country having been swept by intermittent fires. About 30 miles east of Rat Portage the line crossed a divide running easterly to the height of land. This divide throws some of the waters to the south through the Winnipeg river, and some to the north into English river, the outlet of Lonely lake or Lac Seul, which joins the Winnipeg 50

[5] Report of Progress on the Explorations and Surveys, Canadian Pacific Railway, up to January, 1874, by Sandford Fleming, Engineer in Chief, pp. 8, 9.

[6] Ibid. p. 158.

miles below Rat Portage. There is a marked difference between the country on the south and that on the north of this divide. The former is extremely rocky and rugged, while the latter is more level, with extensive tracts of light sandy soil.

Lake Nepigon is the most prominent feature in the country to the east of the section just described. It is some 70 miles long by 50 miles wide, and contains many islands. The descent from the height of land to this body of water is much more rapid than the ascent on its western side, falling some 900 feet in a distance of about 50 miles, and as a consequence there are fewer lakes than in the region to the west. The character of the hills is also changed. Here they are more detached, very precipitous on their northern and western sides, and standing at a greater altitude above the general level of the country. Their general direction is also different, inclining from north and south to northwest and southeast Lake Nepigon discharges into lake Superior by the river Nepigon, and a little to the west the Black Sturgeon takes its rise in the lake of that name and also adds its volume to that of the great fresh water reservoir. Both these rivers are of considerable size, and in their valleys are large tracts of good land and timber of fair quality, consisting of spruce, tamarack, cedar, pitch pine and a sprinkling of white and red pine. From lake Nepigon to Long lake the country maintains the same general character, rising rapidly until the height of land is again crossed in the neighborhood of the latter lake. A divide runs east from the southern end of lake Nepigon separating the waters flowing south into lake Superior from those which run northward, but which ultimately find their way into the same place through the valley of the Nepigon. To the south of this the country is very rough and rocky, and is cut through by the valleys of rivers running from north to south having their sources in the height of land. On each side of these rivers the hills rise from the water's edge steep and precipitous to a height of 400 to 600 feet near lake Superior. Lake Nepigon district.

The country lying between lake Nepigon and the Albany river consists of Laurentian gneiss and granite, alternating with Huronian schists, and as far as exploration has disclosed contains good land only in isolated tracts of small extent. Gneiss prevails on the Albany down as far as the most northern point of the great bend of that river, some distance below Martin's Falls, at which point yellowish limestone strata make their appearance. Lower down these are overlaid by drab and chocolate colored marls and shales. The fossils found indicate the Niagara formation. Martin's Falls is only a rapid with a descent of about 12 or 15 feet, down which light canoes are easily run. From this point to James bay the river is open on an average six months of the year. Hay, turnips and potatoes have been successfully cultivated at the Hudson Bay post here for a long time, and cattle thrive well. Fragments of a hard, banded hematite containing usually about 50 per cent of iron occur in the drift along the Albany. Below Martin's Falls the country on both sides of the river is quite level. The banks are steep and from 40 to 90 feet high. They drain a narrow strip of land on either side, but beyond this great swamps appear to extend. On Albany river.

Valley of the Kenogami.

Dr. Bell says of the valley of the Kenogami, a tributary of the Albany which takes its rise in Long lake, twenty miles only to the north of lake Superior: "The English or Kenogami river flows through a level country all the way from Long lake to the Albany. Some ridges and knolls of syenite and gneiss occur at intervals, in the upper part of its course; but even these disappear below Pine lake, and the whole surface becomes uniformly level. Banks or terraces of brown loam and gravelly earth, varying from ten to about forty feet, but averaging about twenty in height, occur nearly all along the sides of the river, as far as we explored it, and also around Pine lake. In rapid parts, these terraces approach close to the water's edge; but at other places they generally recede, on one side at least, a short distance from the river. The soil on the top of the banks, and to some distance from the river, appeared very good in most of the localities examined. The timber consists mostly of spruce, balsam-fir, white cedar, tamarack, white birch and aspen. Some of the larger spruces and tamaracks measured between five and six feet in girth at five feet from the ground; but the average diameter of the larger trees would be about eighteen inches. In the last twenty or thirty miles explored, the ground became swampy on going back to a short distance from the river on either side, the timber consisting of small spruces, cedars and tamaracks. The Indians report the same conditions to prevail over a very large area in this section; while nearer James bay the ground is still lower and more swampy, and is interspersed with large and very shallow lakes, and with bogs and marshes, in which great numbers of water fowl breed in security, their haunts being inaccessible, either on foot or by canoe. Some of the bogs are said to be so wide that one cannot see across them, and the only objects that break the outline of the horizon are a few stunted black spruces, standing far apart."[7]

General features of the country between lake Superior and Albany river east of lake Nepigon.

"In a general way," Dr. Bell sums up with reference to the district lying between lake Superior and the Albany river, "it may be said that the whole country examined north of the hilly region around lake Superior and east of lake Nepigon, is comparatively level, with a sandy soil, generally dry, but in places interrupted by shallow swamps and low rocky ridges. The soil appears to be for the most part naturally poor, and over a considerable proportion of this area it has been rendered worse by the burning out of the vegetable mould by repeated fires. The old timber consists in order of abundance of spruce, balsam fir, tamarack, white birch, aspen, white cedar, Banksian pine or cypress and balsam poplar; but after the fires the new growth consists principally of white birch and aspen. . . . The climate appears to be no worse than that of parts of the province of Quebec which are already inhabited. In going from lake Superior to the valley of the Albany no difference was observed in the character of the vegetation, which may be accounted for by the greater elevation of the southern part, together with the cooling influences which lake Superior exerts upon it. Oats and barley have been successfully cultivated at Long Lake House, while hay, potatoes, and all the

[7]Geological Survey Report 1870-71, pp. 340-41.

ordinary vegetables thrive remarkably well. Last year the potato tops had not been touched by frost up to the time of harvesting, which was during the first week in October."[8]

Along the Ogoké river.

The largest branch of the Albany river from the south side above the Kenogami is the Ogoké, which is described by Dr. Bell as averaging where examined by him about 500 feet in width, with large lagoons and marshes on either side, and from 50 to 60 feet deep in the middle. He was informed that it maintained the same dead water character for a long distance both above and below this point, and that in consequence it was well adapted for steamboat navigation on this part of its course, but he understood that it spread out to a great width and became very shallow after it reached the palæozoic rocks farther down.

The district from Long lake to the Ottawa river.

Of the country stretching from Long lake to the Ottawa river across the several tributaries of the Moose, the section south of the height of land is more forbidding in its general aspect than that lying to the north. In many places the lofty hills of primitive rock have been swept bare of every trace of vegetation by fire, and present a most formidable and dreary appearance. The northern section is in marked contrast to all this; at a short distance north of the height of land the country becomes level and in some places swampy, the latter characteristic, perhaps due in part to the dense growth of timber which covers it, fires having been much less frequent in this section. There are many tracts of fair land in this northern slope, and there can be little doubt that were the country cleared and drained, the effect on soil and climate would be as marked as it has been in the settled parts of Ontario. But even in the region which drains into lakes Superior and Huron there are many areas of cultivable land, notably in the valleys of the rivers, and if there were a general demand for it there can be little doubt that the sharpened eyes of land-hunters would discover that numerous sections now deemed unfit for settlement have a soil capable of supporting a thrifty and industrious population. A very large portion of the country through which the Canadian Pacific line was originally projected is covered with a dense growth of moderate sized timber, consisting of balsam, spruce, poplar, white birch, some tamarack and occasionally groves of white and red pine, and at many points indications of valuable mineral deposits have been observed.

LATER SURVEYS BY C. P. R. ENGINEERS.

From lake Nipissing to the Mattagami river.

In 1880 several surveying parties were again at work in the interest of the Canadian Pacific Railway trying to locate a line from the Southeast bay of lake Nipissing to Port Arthur (then Prince Arthur's Landing) which would be more favorable than any previously explored. Mr. W. A. Austin had charge of the eastern section, from lake Nipissing to the Mattagami river, a distance of 116 miles. Beginning at the east end, he says that in the first seventy miles some good land but not of any great extent was gone over, the surface being rocky and hilly. From the seventieth mile the land was more level, now sand, sand and gravel, and sandy loam, with swamps in various

[8] Geological Survey Report 1870-71, p. 350-351.

places. A small area of good land was found near Mattagami lake. The timber of the first half of the line was chiefly white pine, spruce, birch, tamarack, balsam and maple ; of the latter half spruce, pitch pine, white and red pine, balsam and some tamarack and maple.

From the Mattagami river to the Moose.

The next section west from Mattagami river to the Moose, about 116 miles, was explored by Mr. C. H. Gamsby, who divided the ground into four sections from west to east.

(1) From the Moose to the Kapaskasi river.
(2) From the Kapaskasi to the Nestodjiostone river.
(3) From the Nestodjiostone to the Ground Hog river.
(4) From the Ground Hog to the Mattagami river.

Section 1, about 32 miles long and from 30 to 60 in width, was composed largely of a clayey loam surface mixed with vegetable mould, identical with the soil in the vicinity of New Brunswick House where fine crops of coarse grain and roots had been grown the previous season. Fully seventy per cent. of the soil in this section could be classed as very good.[9] The remaining thirty per cent. is composed of about ten per cent. inferior, the rest being small muskeg and gravel ridges. Timber, chiefly birch, poplar, cedar, spruce and tamarack is found in great abundance, and in many localities of large size, the cedars being particularly fine. Section 2, which was twenty-two miles long and of less width than section 1, was broken by high granite ridges. The clay and marl soil only occur in belts, being in the interval replaced by sandy loam mixed with boulders. Perhaps fifty per cent. of the soil would rank as good, the remainder, though not worthless, would be classed as inferior. A considerable part of this section had been burnt over, and timber was found only in the swamps in such portions. In the unburned areas a moderate quantity of white pine was found mixed with the varieties prevailing in section 1. No muskegs of any size occur in this section. Section 3, about sixteen miles in length, had a fair proportion of clay soil extending from Nestodjiostone river four miles southeasterly to the Pishganagamee. In the rest of the section the soil was sandy, with boulders, though Mr. Gamsby found good crops of barley and roots growing at the

[9] A subsequent examination in 1885 by Mr. Borron convinced that gentleman that Mr. Gamsby's estimate was much too high. Dr. Bell's impressions of the district near this locality are thus recorded in the Geological Survey report, 1877-78, part C. pp. 7-8:

"But after passing the swampy grounds north of Missinaibi lake, the traveller cannot fail to be struck by the abundance and the general fertility of the soil exposed in the banks of the Missinaibi and Moose rivers all the way to Moose Factory. It consists mostly of a brownish, somewhat gravelly loam or earth, resting upon till, and sometimes upon stratified clays or the solid rock, which, however is seldom seen except at the principal rapids and falls. But in the central third of the section between lakes Superior and James bay, or from the Brunswick to the Long Portage, a light colored clay usually forms the surface. I examined the country for a mile or two back from the river in several places for the special purpose of ascertaining the nature of the soil, and found it excellent in all cases, but tending to become more swampy in receding from the river in the Devonian region below the Long Portage. Samples of the soil were collected in a few places for subsequent examination. In traversing such a great extent of almost unbroken wilderness, one is apt to forget the possible value of this vast region for agricultural purposes. But the examples of the farms at New Brunswick House and Moose Factory show, upon a small scale, what might be extended over a great part of the country. I have no doubt that at some future time this territory will support a large population."

Hudson's Bay Company's post at Groundhog lake. The timber of this section was very similar to that of number 1, except that red pine took the place of spruce. Considerable quantities of red and white pine of good size were found throughout the whole of this section. Section 4, forty-four miles long, was higher and more broken than any of the others, and displayed a good many rocky ridges. The soil was sandy loam with boulders, and may be classed as inferior. There was a great abundance of red pine growing in this section. It was tall, straight and sound, varying from four to fourteen inches in diameter ; probably not up to the standard for lumber for exportation, but of great value for domestic uses and occupations."[10]

BORRON'S CONSERVATIVE VIEWS.

Mr. Borron is perhaps more inclined than any of the other explorers to speak with reserve as to the general suitability for agricultural purposes of the Hudson Bay slope. Referring to a large portion of the central plateau lying between the Missinaibi and Kapuskasing rivers examined by him in 1885, and covering part of the territory described by Mr. Gamsby, Mr. Borron says : "I do not think we should be safe in assuming that more than one-third is arable in any reasonable sense of the term"; but he adds that nevertheless there is a large proportion of the land which has a good soil, and will be valuable for hay and pasture, if not also for root crops. According to Mr. Borron, in the flat country south of James bay, underlaid by the Devonian limestone, there are three classes of agricultural or pastoral land : (1) The strip immediately adjacent to the waters of James bay, from a quarter of a mile to three or four miles in width, on which there is naturally fine pasture and much marsh hay. A large number of cattle could be supported on this strip. (2) The low-lying bottoms, points and islands of alluvial soil found at intervals on the rivers in the territory. The land is good, but generally flooded in the spring, and while of considerable extent in the aggregate, rarely occurs in blocks of sufficient size to form a large settlement. (3) A narrow strip along the margin of the rivers, varying in width from a quarter to half a mile. Back from the rivers it is Mr. Borron's opinion that the whole country from the Abittibi on the east to the Albany on the west, and extending many miles inland from James bay is a vast level clay plain overlaid almost everywhere by peat bogs of very extraordinary extent. In the region to the south of this flat country, and intermediate between it and the height of land, is the belt of land characterized by numerous rapids and falls in the rivers which traverse it. While there is in the aggregate a large quantity of arable land, principally clay, and a much larger area still that would form fine pastures and meadows, Mr. Borron's explorations have lead him to believe that muskegs or peat mosses overspread the greater part of this section also. In the height of land region itself Archæan rocks constitute a large proportion of the surface, and frequently rise into low ridges or hills. Between these are lakes, marshes and swamps. The soil on the ridges is rarely clay, but is generally light and stony in character. A small propor-

Classes of farm land south of James bay.

[10] Dom. Sess. Papers, 1880-81, Vol. XIV., No. 23, p. 12 *et seq.*

tion only of the land is suitable for grain growing, but nearly all of it will afford more or less pasture. The area occupied by peat mosses is relatively small compared with that covered with timber. The wetness of these plains, in which the soil is almost universally clay or underlaid with clay, and which the natural drainage system is insufficient to remedy, appears to Mr. Borron to be the principal cause of the formation of these great bogs. The depth of the main rivers below the level of the adjacent country is very slight, and their tributaries are consequently short and of no great volume. As a consequence, the surface at some little distance inland remains permanently wet, thus providing, in conjunction with the northern climate, the most favorable conditions for the growth of the sphagnum moss which forms the bulk of these peat marshes. An extract from Mr. Borron's report of 1880 gives a graphic description of the peat country, and at the same time utters a warning against judging the interior region from the land and vegetation seen along the river routes.

The peat country.

' The traveller, visiting Moose Factory for the first time, following the usual routes, and seeing so much only of the country as may be visible from his seat in a canoe, is almost certain to form too favorable an opinion of the character and the resources of the territory north of the height of land. The fertility of the soil, the size and healthiness of the timber, and the luxuriance of the native grasses, as seen in many places on the banks of the rivers, inevitably tend to the belief that this is the general character of at least the adjacent land. A more thorough examination of the region thus travelled through has convinced me that the quantity of arable land fit for settlement is not nearly so great as I had supposed it to be. Those who have read the preceding narratives of my explorations this season cannot fail to have perceived that the fertile appearance of the land on the immediate banks of the rivers is very delusive and misleading. Over and over again it must have been noticed that on going inland at those points where on the banks of the rivers the soil and timber presented the most promising appearance, we found that the ground became wetter and wetter, that sphagnum moss covered the surface to a greater and greater depth, and that generally in less than half a mile we came to where peat had been formed; that as these peat mosses increased in depth, first the poplar, aspen and birch would give place to spruce, and to what is called in this country juniper or tamarack; and secondly, these last would diminish in size until they were little more than mere shrubs thinly scattered over the widespreading surface. Nor were these trees healthy wherever the peat had attained to any considerable thickness. On the contrary, they were not only stunted, but scrubby, and frequently dead. They were draped, too, with a species of parasitic hair-moss of a gray or black color, which hung in long dishevelled tresses from the dead and dying branches, and imparted to the whole scene a most dismal and funereal appearance."[11]

[11]Report on the Basin of Moose River, 1890, pp. 8-9.

NEW REGIONS OPENING FOR SETTLEMENT.

A fertile belt in the Rainy River basin.

In the valley of the Rainy river at the extreme western end of the Ontario Hinterland there is a fertile belt of rich alluvial soil greatly in contrast with the peat wilderness just described, the extent of which is variously estimated at half a million to four million acres. The latter figure no doubt includes the agricultural land of similar character on the banks of the Seine and other streams emptying into Rainy lake and on some of the rivers flowing from the east into Lake of the Woods. A number of towships on Rainy river were surveyed into farm lots by the Dominion Government when the territory was in dispute and some have since been laid out by the Ontario Government, and the land has been opened for settlement under the Free Grants Act. The timber of the district includes pine, poplar, birch, basswood, oak, elm, ash, soft maple, balm of Gilead, balsam, spruce, cedar, and tamarack, and a considerable business is done in rafting logs down the Rainy river from Rainy lake and its tributaries. The drawback under which the section has so far labored is lack of railway communication, for want of which it is practically isolated in the winter months. Notwithstanding this, a prosperous settlement is being formed, and the recent discoveries of gold in the country around and north of Rainy lake are likely to give it an impetus by providing a ready and nearby market for the agricultural products of the valley. It is a happy combination of circumstances when mining and agriculture can be carried on alongside each other. A population engaged in mining has usually little opportunity or inclination to till the soil, even if the surface of their rocks were more propitious than it generally is, and consequently there is an unceasing demand for the very articles which the farmer produces from his land, for grain and flour, for beef and pork, for butter and cheese, for milk and vegetables. Indeed there is no better market than a mining camp for everything grown on a farm, and no one is more willing to pay a good price for what he wants than a miner earning good wages in a paying mine. The gold finds of the Rainy lake country are attracting a good deal of attention, and the rush this spring to the field is likely to be great. It is to be hoped that operations will be conducted not only with vigor, but with discretion, and that capital will not be thrown away in erecting costly plants before veins are thoroughly proven both as to extent and quality. Failures from this and similar causes have been too common in Ontario, and have helped largely in fastening upon the business of mining that reputation for risk and uncertainty which it holds to-day in the public mind. The fact that the gold in this district occurs largely in bedded veins, while by no means fatal or perhaps even prejudicial to ultimate success, should be an additional reason for carefulness. It Rainy lake should take the place among the gold producing fields of the continent which sanguine men anticipate, the future of the agricultural belt along the Rainy river is likely to be a prosperous one.

Agriculture and mining.

A fertile area at Wabigoon lake.

It is almost invariably the case that a close examination reveals a much larger proportion of good land in a new district than had been accorded to it at first glance. This has had a recent illustration in a part of western Ontario traversed by the Canadian Pacific Railway. When that line was

first opened the general verdict of travellers from Port Arthur to Rat Portage was that the whole country was a barren stretch of rock and swamp. It is now being found that such is by no means the case. In the vicinity of Wabigoon lake, north of the height of land, there has been found a tract of excellent clay land extending over an area equal to that of three or four townships. The Government of the province is taking steps to prove the capabilities of the district by establishing a pioneer dairy farm near Barclay station, on the north side of Wabigoon lake and about the centre of the fertile area. A market will be found in the dining cars of the Canadian Pacific Railway for all the milk, butter and cream that can be raised on the farm, and the likelihood is that the supply will fall short of the demand, for there is a long reach of unsettled country on both sides of Barclay, and hungry passengers must be fed. There is a considerable water power on the Wabigoon river, which flows out of Wabigoon lake and joins the Eagle river, the outlet of the lake of the same name, after which the mingled waters flow into the English river and so into the Winnipeg; and this water power may yet be used for saw-milling and other manufacturing purposes.

The Lake Temiscaming district.

Turning now to the eastern extremity of the province, we find a district probably quite as fertile and at present more accessible than that of the west. From the mouth of the Montreal river, about thirty miles south of the head of lake Temiscaming, northward across the height of land to lake Abittibi, and it is believed by some even to the shore of James bay itself, stretches a vast level clay plain, broken here and there by protruding gneissoid and dioritic or slaty rocks.[12]

In the region north and northwest of lake Temiscaming some twenty-five townships have been laid out and surveyed by the Department of Crown Lands in and adjacent to the valley of the river Blanche, and it is thought that a cultivable area of at least half a million acres, and probably more, is to be found here in one continuous block. Over a sub-soil of rich, calcareous clay a covering of vegetable mould many inches deep has accumulated, the whole being of exceptional fertility. The labor of clearing the land for the plough is rendered light by the comparative smallness of the timber. A very large quantity of spruce grows here suitable for pulpwood, and there is great store of cedar which attains an unusual size. The whitewood of the lake Erie counties reappears here, and oak, birch, elm, sugar maple and hemlock are also found. A demand is springing up for the lands of the Temiscaming district, and access will be greatly facilitated by the line of railway being built by the Canadian Pacific on the Quebec side from Mattawa up the Ottawa river to the foot of the lake, a distance of about thirty miles, for the purpose of overcoming the rapids *en route*.

It is not to be supposed that the districts which have been mentioned are the only ones in which good land occurs, for there are many others in which it is known that there are considerable tracts of a rocky, swampy, or otherwise broken character, but yet containing a sufficient area of cultivable soil to support a large population

[12] An interesting fact is that at the north end of the lake a fossiliferous limestone appears in places, which seems to correspond to the Niagara formation. The denudation of this limestone may in part at least have given rise to the white clay deposits of this district.

Timber of the Hinterland.

Hardly less important than the land itself is the timber which it bears, and the timber wealth of the Ontario Hinterland is varied and great. The principal forest tree and the one with which as yet the lumbering industry chiefly concerns itself is the pine. The home of the pine in Ontario is the Ottawa valley, including the various districts drained by its tributaries, and the country contiguous to Georgian bay and lake Huron. Very extensive groves of white pine (*P. strobus*) and red or Norway pine (*P. resinosa*) originally stood in these sections, disputing the territory with other conifers and the deciduous trees; but bush fires, the arch-enemy of American forests, and the lumberman's axe have made serious inroads upon them. A chief seat of the lumber trade is in the country north of lake Huron, on the French, Sturgeon, Wahnapitae, Vermilion, Spanish, Sable, Serpent, Blind, Thessalon and Mississaga rivers. The pineries here were on a very large scale, and are by no means yet exhausted, though the yearly cut of logs is being brought from farther and farther up the streams. There is however a large quantity of pine to be brought out of the country north of lake Huron. Between the Canadian Pacific Railway main line and Sault Ste. Marie there are considerable tracts of pine not yet brought into the market. The north shore of lake Superior appears to be largely devoid of merchantable pine, but farther west on Rainy lake and Lake of the Woods and in the country to the north and east of these lakes respectively, pine of good quality is now being taken out, though it is of smaller size than that of the east. The rivers running into lake Temiscaming from the Ontario side are important lumbering streams. Large areas of valuable pine still belonging to the Crown are known to exist north of lake Wahnapitae and west of lake Temiscaming, and it occurs plentifully on the banks of lake Temagami and Rabbit lake. While in a general way it appears to be true that the northern limit of the pine in the eastern portion of the province is the height of land, there is little doubt that in the aggregate a considerable quantity is found in the more southerly reaches of the Hudson bay slope. The timber here however does not at present form part of the available supply for lack of means to convey it to market. It is impracticable to float it down stream to the north, and it cannot be brought south until a railway is built. White pine is abundant and of good size on all the head waters of the Moose, and red pine exists farther north than the white. From the Missinaibi westward to the Albany river pine seems to be confined to a few groves of the red variety of no great extent or importance. Between the height of land and the 49th parallel considerable red and white pine are found growing on the ridges. Red pine is frequently met with singly or in clumps on the islands and shores of lake Opazatika, which seems to be on the northern verge of its *habitat*. North of lake Temiscaming white and red pine are found as far as lake Abittibi, though at the latter place the trees are small and scraggy. On the slopes of the hills along both sides of the height of land in this locality pine is abundant and of good quality. At lake Matawagogig on the northern slope of the height of land, pines eight and nine feet in circum-

The home of the pine.

Seats of the lumber trade.

Pine areas of the far north

ference have been noted, and groves of white pine occur in all directions. According to Dr. Bell red and white pine are common all the way from lake Huron to Mattagami lake, and ceased to be observed a short distance below Kenogamisee lake.

Jack pine.

The jack or Banksian pine is a scrubby tree in its southern extension, but is larger and more important in the north, as in the region of the Albany river, where large groves occur in which the trees are about seventy feet in height and two feet in diameter at the butt, with straight trunks nearly free from branches for the first twenty or thirty feet.

Spruce.

The most northerly tree of the continent is the spruce, which is found in greater or less abundance from the great lakes to James bay, and from its plentifulness and the uses to which it can be put, is probably the most valuable tree north of the height of land. It attains good size for lumber purposes in the neighborhood of James bay. " The original timber along the lower stretch of Moose river" says Dr. Bell, "has been mostly burned within the last fifty or sixty years, but wherever the old spruces have escaped they are of larger growth than those seen on any other part of the route from Michipicoten." According to Mr. Charles G. Horetzky of the Ontario Public Works Department, who was twenty-six years ago in the employ of the Hudson's Bay Company at Moose Factory, there is considerable spruce of fair size on the banks of the Moose river thirty or forty miles from its mouth. Specimens three feet in diameter are sometimes seen. The Hudson's Bay Company were at that time in the habit of getting out one raft of spruce timber every autumn containing several thousands of feet which they sawed into lumber at Moose Factory for building and other purposes. But the bulk of the spruce growing on the muskegs or peat mosses on both sides of the Moose is of stunted growth and unsuitable for manufacturing into timber. "There is no tree however" says Mr. Borron, "which possesses in an equal degree the power of adapting itself to all the changes of soil and climate in this northern territory as the spruce. It is consequently the tree most commonly met with from the moment we cross the height of land until we arrive at the coast of James bay. On the rich soil of the sheltered river bottoms it overtops all the other trees, and attains a circumference of from six to eight feet. On the coast and islands of James bay it still holds its ground, but is greatly dwarfed, the largest trees on Charlton island being less than half the size of those just referred to. . . In the aggregate there is an enormous quantity of spruce of useful sizes in this territory."[13]

Valuable timber for paper pulp.

Spruce is also found in the Temiscaming country and on the rivers flowing into lake Huron from the north, whence considerable quantities in the form of 4-foot lengths are every year exported to the paper factories of the United States. On several of the rivers tributary to lake Superior it grows in some quantity, and is there cut for the same purpose and sent to the same market. Spruce is the most desirable tree for pulpwood, the next in favor being the poplar, and the rising demand is adding every year to the value of the spruce growing in Ontario. It has enabled the Department of Crown Lands

[13]Report on the Basin of Moose River, 1890, p. 46.

to begin the process of turning to account such tracts of this timber as exist on the ungranted lands of the Crown by disposing of the right to cut over specified areas. Should the pine forests of the province in time begin to fail under the great and constant demands made upon them and consequently cease to yield to the public revenues the large amounts which they have been and are now producing, it is worth considering whether the spruce forests of northern Ontario cannot in some degree at least be made to take their place.

The American larch, or as it is more commonly called, the tamarack, is widely diffused through the whole territory both north and south of the height of land, and in point of abundance probably ranks next to the spruce. To the south and west of James bay, it is found of largest size on the dry uplands and where there is good soil, but smaller trees are plentiful in the swamps and peat mosses. The tamarack grows plentifully in the neighborhood of lake Temiscaming. Along the line of the Canadian Pacific Railway there is a demand for this timber for use as railway ties. Tamarack,

The balsam poplar grows luxuriantly along the rivers flowing into James bay, and attains considerable size in the neighborhood of lakes Huron and Superior. The common poplar or aspen, largely used as fuel in Manitoba and the Northwest territories, is valued next to spruce as raw material for the manufacture of paper. It is common on the height of land, but particularly on the northerly plateau and the banks of the rivers which traverse the great plain further north. The hemlock is found round lake Temiscaming, but does not appear to occur in any frequency throughout the district spoken of. White cedar grows in the country south of Moose Factory and the Albany river, and is of large dimensions in the vicinity of lake Temiscaming. Of the deciduous trees, maple, oak, elm and ash occur in places south of the height of land and rarely on the Hudson bay slope. poplar, hemlock, white cedar and other trees.

Peat and its Uses.

The peat mosses described by Mr. Borron are estimated by him to occupy an aggregate of 10,000 square miles. While undoubtedly detracting from the agricultural capabilities of this region, very materially these great peat beds have a value of their own. It is not improbable that in the absence of a good quality of coal prepared and pressed peat fuel may come largely into use in Ontario, and if means of transportation are afforded, an inexhaustible source of supply will be opened up in this northern territory. Recent improvements of manufacture give ground for hope that we may soon be put in possession of a really efficient and economic fuel produced from peat. The value of peat as a deodorizer is also coming to be recognized, and in disposing of sewage and waste matter without offense it finds much employment in the cities and towns of continental Europe. In the form of moss litter it is used with great success as bedding for horses and cattle owing to its capacity when dry of absorbing as much as twenty or twenty-five times its own weight of mois- Extent of the bogs, and various uses of peat.

ture. When its use in the stable is ended, it is in condition to be employed as a fertilizer of the highest value. Peat also provides raw material for textile fabrics, and is employed as a preservative packing for fruit and perishable articles.[14]

Mineral Resources of the Hinterland.

An imperfectly explored region,

yet many valuable discoveries made.

Bruce mines.

Silver islet.

Lake of the Woods.

Rabbit and Silver Mountain.

Sudbury.

The mineral resources of the Hinterland are as yet but very imperfectly known. The prospector has been abroad in the region skirting the great lakes, and in that traversed by the Canadian Pacific Railway, and many important discoveries have been made. But even here only a small proportion of the country has been examined with anything like minuteness, and every year is bringing fresh deposits of mineral to light. What the interior of the country may disclose time only will tell, but there is no ground for believing that all the mineral wealth of Ontario is confined to the southern region. Among the earliest mining operations on a large scale in the province were the works carried on at the Bruce mines, on the north shore of lake Huron, where upwards of $3,000,000 worth of copper was extracted between 1846 and 1876. The celebrated silver mine at Silver Islet in lake Superior proved extraordinarily rich, and from a little space scarcely bigger at the surface than a ballroom about $3,250,000 worth of silver is believed to have been taken until the mine was abandoned in 1884 at a depth of 1,230 feet About the year 1878 gold was found on Lake of the Woods, and subsequent exploration has made known an extensive area of gold-bearing rock in this region. The silver mines of the Rabbit and Silver Mountain districts were discovered in 1882, and were worked with suceess until the falling price of silver rendered them unprofitable. The sudden springing into prominence of the Sudbury copper-nickel mines is a notable feature in the history of mining in Ontario. The opening of these deposits was a direct result of the construction of the Canadian Pacific Railway, the first body of ore having been laid bare in 1882 by a cutting on the main line where is now situated the Murray mine of H. H. Vivian & Co. It was not until after the mines had been worked for some time that the presence of nickel was suspected in the ore. Now the Ontario mines contest with those of New Caledonia the supremacy of the world's nickel market. It is asserted that one Canadian company contributed as much as seventy per cent. of the total output in 1894. The manner in which the nickel ore occurs and the process of working it are well known, and do not require description here. With the increased demand which is sure to follow the extended use of nickel in the arts, a period of even greater activity and prosperity for the nickel mines of Ontario may be looked for. Gold was found in some quantity north of Bruce mines on the location now owned by the Ophir Mining Company, and in the autumn of 1893 the promising gold belt of the Rainy Lake country was first brought to the attention of the

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[14] For a fuller account of the peat deposits of Ontario and elsewhere and their utilization for fuel and other purposes, see First Report Bureau of Mines, p. 180, Second Report, p. 195, and Third Report, p. 139.

public. This district was the scene of considerable activity last summer, and a good many finds of greater or less promise were made. The present spring bids fair to witness a rush to this latest of the gold fields of the continent.[15]

Galbraith and Rainy lake.

Some very rich samples of gold-bearing quartz have come from the vicinity of lake Wahnapitae, and it is quite possible that that locality may yet see gold mining operations being conducted on a considerable scale. All the gold hitherto found in Ontario has been in place and not alluvial. Rumors of placer fields are heard from time to time. Sometimes they are located on one or more of the rivers emptying into lake Huron; sometimes they are spoken of as existing near the height of land, and the latest is said to be at Shoal lake on the Seine river, a tributary of Rainy lake. If anything tangible is really known of these alleged gold diggings, the possessors of the information have seen fit, not only to keep the knowledge secret, but to make no use whatever of it themselves. The copper-bearing rocks of the south shore of lake Superior have their counterparts on the northern side, and at Point Mamainse deposits of native copper and copper ore have long been known to exist, and indeed were exploited to some extent many years ago. Exploratory work has recently been resumed, and has satisfied the proprietors that the property is likely to be a very productive one. Copper also occurs in considerable quantity on Michipicoten island Very extensive deposits of excellent magnetic iron are known to exist at Gunflint lake on the boundary between Ontario and Minnesota, on Hunter's island, on the Mattawin and Atik-okan rivers and elsewhere west of Port Arthur. North of lakes Superior and Huron iron is also found.

Lake Wahnapitae.

Point Mamainse.

Iron ores.

Huronian Areas and their Minerals.

The azoic rocks of northern Ontario, comprising the Laurentian and Huronian systems, occupy so far as yet known, almost the entire space between the great lakes and the southern boundary of the palæozoic formations inland from James bay. The Laurentian has long had the reputation of being comparatively barren of minerals, while the Huronian is regarded as pre-eminently the system in which mineral deposits may be looked for. With the exception of the silver veins west of Thunder bay and the copper of Point Mamainse and Michipicoten, which are respectively in the Animikie and Nepigon formations, the two lowest members of the Cambrian system, the mineral deposits above referred to are found exclusively in Huronian rocks. The great Huronian belt extends eastward from the south-

Belts of the mineral bearing Huronian formation.

[15] The existence of gold and other minerals on Rainy lake was known previous to 1890, as will be seen by the following extract from the evidence of John McQuarrie in the Report of the Commission on the Mineral Resources of Ontario, published in that year (p. 64). "There are some fine specimens of gold, iron, and silver on Rainy lake. Mr. Alex. Baker, of Fort Frances, has some splendid specimens of gold and silver which he claims came from there, and also lignite. They were found on the north shore of Rainy lake. Mr. Thomas Sheppard also had specimens. The quartz was claimed to be gold-bearing although it does not show free gold, and on analysis there proved to be considerable silver as well. Several specimens have been brought in by Indians, but they want money before they will tell where the deposits are."

east corner of lake Superior along the north shore of lake Huron, and thence northeastward to the provincial boundary at lake Temiscaming, embracing within its limits the copper deposits of Bruce mines, the gold of the Ophir mine and lake Wahnapitae, and the copper-nickel ores of Sudbury and vicinity. Huronian areas also stretch across all the branches of the Moose river, northward from the Montreal river to beyond lake Abbittibbi, along the Groundhog river and lake Mattagami, and around Michipicoten at the northeast angle of lake Superior running west and north, and extending inland to Dog lake. Other belts are those which stretch from the Pic river to Mattamasagami lake and westward to Nepigon bay, which run eastward from lake Nepigon to Long lake, and which occupy the basins of Rainy lake and Lake of the Woods. Another belt starts between these two last named lakes, and runs northeastward to and beyond the line of the Canadian Pacific Railway. Huronian rocks are also to be found at both ends of lake St. Joseph and along three sections of the Albany river, above the point at which the Devonian formation begins. The greater part of these areas is virgin soil to the prospector, and almost nothing is known of their resources; but it is reasonable to suppose that the same richness and variety of mineral wealth which characterize the Huronian formations elsewhere in the province will be found in these northern extensions of the same system. Large trap dykes are frequently found crossing the rivers and traversing the country for miles, and following the result of experience in other places, the prospector would probably find it of advantage to give such localities a thorough inspection. The researches of Dr. Bell and Mr. Borron, largely confined as they have been to the immediate neighborhood of the rivers and lakes, have made known a considerable number of mineral deposits of the bulkier and more easily recognized kind. So far as the rare metals such as gold and silver are concerned, it usually requires close research to discover them even when they are the immediate object of quest. Many sections of the province have been examined for their geology without suspecting the presence of valuable minerals afterwards discovered by the patient and experienced prospector.

A district of promise to the prospector.

THE PALÆOZOIC PLAIN.

Minerals of the palæozoic rocks on the Hudson Bay slope.

One practical difficulty that will confront the explorer on the Hudson Bay slope is the depth of overlying drift which conceals the fundamental rock from view over so considerable a portion of the territory. The southern edge or belt of the palæozoic plain has so far furnished the greater number of mineral discoveries, consisting as enumerated by Mr. Borron of lignite or brown coal, iron ore, kaolin or China clay, potter's clay, the finest of sand for glass-making, gypsum, fire-clay and brown and yellow ochres. Some indications have also been noted of petroleum and natural gas.

The existence of lignite on the Missinaibi or north branch of the Moose river, has long been known to the officers and servants of the Hudson's Bay Company. It outcrops at various points on the river from Big Rapids about half way between Moose Factory and the Long Portage, to Coal Brook some eight miles below Long Portage, the distance between the two points being by the river nearly 60 miles. At Big Rapids borings made by Mr. Borron

in 1890 showed the bed of lignite to vary in thickness from two to four feet. It was unsatisfactory in quality, being composed principally of wood or tree trunks, imperfectly carbonized and a good deal mixed with sand. At Coal Brook Mr. Borron made as thorough an examination of the deposits as the time and tools at his disposal would enable him to do. He states the results he obtained in the following words: "The lignite and its associated clays which in 'coal measures' of greater age would be black shales are found in much thicker beds than I expected. They vary, as will have been seen, from one or two feet to nineteen feet in thickness. What proportion the coal bears to the shale in these beds, owing to the mixed condition in which the auger brought up the material of the different bands passed through, is left more doubtful than I could have wished, and only to be determined by a very considerable number of analyses of carefully taken samples. As a matter of opinion and judging from the appearance of what was brought up by the auger, I should say that in the deepest and apparently thickest beds not less than six feet or probably more than nine feet may be lignite coal."[16]

Lignite.

The quality of the lignite is ordinary. A sample brought from Moose river by Dr. Bell in 1875 and analyzed by Mr. Hoffman of the Geological Survey proved to contain about 46 per. cent. of fixed carbon and 39 per cent. of volatile combustible matter, with 12 per cent. water and 3 per cent. ash, and was pronounced very similar to the lignite of the Souris valley (Manitoba) and of the Blind Hills and Woody Mountains (N. W. T.) Lignite is also found on the Mattagami and Abbittibbi branches of the Moose, on the Albany river at its junction with the Kenogami and on the latter river itself. As to the area over which it occurs, Mr. Borron remarks, speaking of the Coal Brook deposits: "The establishment of the fact that these beds underlie at all events the greater part of these drift or glacial deposits, is, I think important in relation to the extent or area occupied by the lignite. Taken in connection with the existence of lignite on the Mattagami river under very similar circumstances, I am of opinion that there is probably a continuous belt of lignite-bearing country between these two points, which are about fifty miles apart, and that it may extend a considerable distance west of the Missinaibi and east of the Mattagami. . . . . I have no data to guide me in forming a reliable opinion as to the width of this belt, should it prove continuous between the points named, but I hardly think it will be less than ten or more than twenty miles."[17] Lignite is also reported to have been found on Lake of the Woods and Rainy lake.

Some slight evidence has been adduced by Dr. Bell indicating the possibility of the occurrence of bituminous coal on the Albany river. On a small island below Martin's Falls he found in 1871 some loose fragments of a bright bituminous coal. He was informed by the Hudson's Bay Company officers that coal had never been brought into the country, and considering that the conveyance of even light and valuable goods is so expensive in this region, he says this is only what might have been expected. Dr. Bell accordingly

Bituminous coal.

16 Report on Basin of Moose river, 1890, p. 68, 69. 17 Ibid. p. 69.

concluded that the coal could not have been brought there by human agency. No coal beds, bituminous or other, or any areas of carboniferous rocks were seen or heard of, and though it is far from impossible these may exist, there is really nothing to warrant the belief that they do.

Anthracite coal.

An impression has gone abroad, sometimes stated in very positive terms, that extensive beds of anthracite coal are to be found on the Hudson Bay slope or on the islands or shores of the bay itself. The alleged existence of these beds together with the great deposits of clay ironstone which are undoubtedly found, is sometimes urged as an argument for the construction of a railway to James bay. It would be a happy thing for the province if these areas of coal were real, but the present state of our information does not lead to this conclusion. The principal fact upon which the anthracite theory rests, so far as can be ascertained, is that Dr. Bell when at Moose Factory in 1875 was presented by an Indian with several specimens of a mineral having all the characters of a fine anthracite, except that it contained only a very trifling amount of ash. The specimens were said to have been found on Long island, south of the Great Whale river. Dr. Bell was also informed by a Hudson's Bay Company officer that the Indians had reported the occurrence of a similar mineral some miles inland from Little Whale river, and Mr. Low of the Geological Survey has obtained like samples in the interior of Labrador, many miles inland from Hudson's bay. No outlying members of the carboniferous series have yet been observed on the Hudson Bay slope, at any rate in Ontario; and although even their absence if demonstrated would not be in itself conclusive proof against the existence of coal, yet the evidence in favor of the occurrence of true coal is at the present time of the most meagre kind.

Iron ore.

A very large body of iron ore is found on the Mattagami branch of the Moose river at the foot of the Grand Rapid, about eighteen miles below the Long portage. The deposit is thus described by Dr. Bell: "Its position is on the northwest side of the river, at the foot of the rapids. It runs along the foot of the cliff for a distance of upwards of 300 yards almost continuously, with an exposed breadth of 20 to 25 yards. The highest points rise about 15 feet above the level of the river. The surface is mottled, reddish-yellow and brown, and has a rough spongy or lumpy appearance like that of a great mass of bog-ore. At the surface and sometimes to a depth of several inches, it is a compact brown hematite, occasionally in botyroidal crusts with a radiating columnar structure; but deeper down it is a dark-gray, compact, very finely crystalline spathic ore, apparently of a pure quality. The brown hematite evidently results from the conversion of the carbonate. The former yields according to the analysis of Mr. Hoffman, 52.42 per cent. of metallic iron, while the latter shows a very small amount of insoluble matter; indeed there is chemically little room for impurities, since it gives rise to so rich a brown hematite."[13] Mr. Borron adds his testimony from personal observation that the deposit is of large extent. He is satisfied "that any quantity of this ore can be obtained at a very low rate;" and that "associated as it is with lignite and peat for fuel it will

[13] Report of Geological Survey, 1875-6. p. 321.

unquestionably be mined and smelted on the spot at no very distant day." Mr. Borron also notes the presence of the same kind of ore *in situ* on the Oba river, about 20 miles above Mamattawa, and has observed indications of its presence on several other rivers. In his opinion it will be found when wanted in many places at or near the southern edge of the Palæozoic area. This is the sort of ore which is worked so largely in England and forms the basis of her enormous iron industry. A deposit of specular iron ore containing by analysis 39.41 per cent. metallic iron is mentioned by Dr. Bell as occurring on the east branch of the Montreal river. In the Nastapoka islands on the east side of Hudson bay and outside the limits of Ontario very extensive beds of carbonate of iron occur, carrying as high as 25 per cent. of carbonate of manganese—a valuable ore for the manufacture of spiegeleisen used in making Bessemer steel. The average thickness of the iron band, says Dr. Bell, is probably not less than 20 feet, and it appears to run through all the islands of the group, a distance of about 90 miles, exclusive of the more northern members which are more widely separated. The band is made up of layers a few inches in thickness. The abundance of the ore is its great feature. Forming the uppermost band on nearly all these large islands, where the dip is so low and the underlying strata confined to the cliffs along their eastern sides, the iron-stone beds are spread over the greater part of their areas, which in the aggregate amount to many thousands of acres. The islands being destitute of timber and the rocks much shattered by the surface water and the frost, the ore ready broken may be gathered up in inexhaustible quantities. The islands offer good shelter for vessels and the ore might be conveniently loaded in many places.[19]

Gypsum.

Banks of gypsum from ten to twenty feet high occur on both sides of the main Moose river between 31 and 38 miles above Moose Factory. The bank on the southeast side runs for about two miles; that on the opposite side about half that distance. The upper portion of the bed is mixed with marl, but ten feet in thickness at the bottom consists of solid gypsum. It is the ordinary hydrous saccharoidal variety, and mostly of a light bluish-gray color, a small proportion being pure white. The bed could be easily and inexpensively worked, and the gypsum utilized if wanted for fertilizing and other purposes, for which an article of a pure white color is not required. Dr. Bell remarks that the geological age of these deposits cannot be far from the Onondagan formation, and it would not be surprising if salt should also be found in the rocks with which they are associated.

Kaolin.

Kaolin or China clay suitable for the manufacture of porcelain is not known to occur in older Ontario, but in his report for 1880, Mr. Borron describes a large deposit on the Missinaibi branch of the Moose, about five miles below its junction with Coal Brook. It forms part of an immense bank or mound of beautiful white sand which extends along the river for at least a mile and rises to a height of not less than one hundred feet. An examination by Mr. Hoffman of the Geological Survey showed that the material formed with water a plastic mass, burned white, and might be said to be infusible. It is well adapted for the manufacture of all kinds of refractory ware, *i.e.*,

[19] Report of the Second Hudson Bay Expedition, 1885, p. 60.

fire brick, lining for grates, crucibles, scorifiers and the like. If employed for fine ware it would require to undergo preliminary treatment to free it from the numerous fine scales of mica which it contains. The sand forming the bulk of the bank is composed of pure translucent grains of quartz, with an occasional fragment of undecomposed felspar, and in the judgment of Mr. Borron, who has had some experience in glass-making, is greatly superior for this purpose to any obtained in either England or Scotland. The whole deposit is evidently due to the decomposition of granite, and doubtless owes its present position to the agency of ice and water.

Ochre, pyrites and natural gas.

Brown and yellow ochres are found on the Mattagami river between Grand Rapid and Long Portage. Iron pyrites also occurs on this river, as well as copper pyrites, the latter at a point about 25 miles below Kenogamisee lake. The bituminous Devonian limestones of the Abbittibbi river not far south of James bay contain indications of petroleum. Natural gas is continually rising to the surface in considerable volume at a place called Bubbling Water on the Missinaibi, a few miles above the junction of the Opazatika. Whether its presence is due to lignite in the bed of the river has not been determined. The immense banks of clay exposed on the rivers of this region may in many places be found suited to the manufacture of brick, and perhaps other articles of a like nature, should the march of events ever give rise to a demand for them in this hitherto untenanted country.

The foregoing enumeration of the known mineral deposits, limited as it is almost wholly to the river valleys where alone has any exploration taken place, gives good ground for the belief that when the extension of population and transportation facilities to this region confer a value upon its minerals, they will be found in quantity and richness sufficient to form the basis of a large and important industry.

Ontario's Sea-side.

On the shore of James bay.

The fact that the northern boundary of Ontario is composed of 200 miles of the shore line of James bay makes it possible for this province to claim rank as a maritime power. In order to obtain the advantage of her situation, the possession of a good seaport is a prime requisite. Unfortunately all accounts go to show that there are no good harbors on that part of the shore line which falls to the province's share. The mouth of the Moose river, which would be the most natural and convenient site for such a port, is extremely shallow and possessed of a very poor approach from James bay, in addition to which the bay itself for a long way out from the shore is of very inconsiderable depth The Hudson's Bay Company's boat, which is usually only a bark of a few hundred tons register, is obliged to cast anchor in the bay six miles from the mouth of the river, on the seaward side of a bar one mile in width. There is a channel on the bar about four hundred yards wide and not more than fourteen feet deep, through which at the rise of the tide the vessel may float in and anchor at "Ship Hole," where there is about eighteen feet of water, eight miles below Moose Factory. This post, which is one of the oldest of the Hudson's Bay Company's trading places, having

The harbor at Moose river,

been first established in 1675, is situated on Moose island, one of a group occupying a considerable portion of the river's bed for some miles up. Above, between and below these islands are numerous sandy shoals, those near the mouth of the river being laid bare at low tide. The channel is closely buoyed all the way, and on the departure of the boat for England the buoys are at once taken up by the Company's officers to prevent their being frozen in. It is necessary also on the approach of winter to haul up on the banks of the river all the sailing craft employed at the post, even to schooners of ninety or a hundred tons burden, to prevent damage or destruction when the ice breaks up in the spring.

The work of dredging the harbor at the mouth of the Moose river with the object of providing accommodation for sea-going craft would be a task of very great magnitude, probably far transcending the benefit to be derived from it. This extraordinary shallowness of the Moose at its mouth and for miles up stream has given rise to the opinion on the part of some that the river does not carry down to James bay the whole volume of water which it receives in its course, but that some portions of it are lost in the muskegs which it traverses in its lower reaches.[20]

On the possibility of utilizing the harbor at Moose river for purposes of navigation, Mr. A. P. Low of the Dominion Geological Survey makes the following remarks : and the possibility of its improvement.

" The eight miles from the Ship Hole to Moose Factory is in places very shoal and is rapidly filling in its upper part so that the Company's schooner, drawing eight feet of water, can only come within about two miles of the Factory, whereas a few years ago her cargo was discharged close alongside that place. If a railway should be built to this harbor its terminus will need to be at Ship Hole ; and to reach it a long and expensive line of embankment will have to be built from the south shore, across sand and mud flats, partly bare at low water, and owing to its exposed position it would need to be correspondingly strong to withstand the force of water during the late fall gales. If approached from the north side a large bridge will be required to cross the channel to the " Ship Sands," a low, flat, muddy island, partly covered with water at high tide, and lying close to the Ship Hole ; in either case the terminus will have to be built largely on made ground. As the present anchorage, six miles without the bar, is in only thirty-six feet, and as the water gradually shoals towards the river's mouth to a depth of fourteen feet at high water on the bar, and is only eighteen feet at low water at the Ship Hole, with a less depth of water for the four miles between it and the bar, it will be seen that to fit this harbor for the entrance of moderate-sized steamers, with a draft up to twenty feet, extensive dredging operations will be necessary for almost the entire distance from the outer anchorage to Ship Hole."

The mouth of the Albany is no improvement on that of the Moose. Indeed in the opinion of Mr. Low the natural conditions there are even worse. Similar conditions at Albany.

[20]Such is the opinion of Dr. Newnham, Bishop of Moosonee, who says the waters of the largest rivers are so shallow in summer as to make canoeing difficult.

[21]Geological Survey Report, 1887-88, pp. 21-22 J.

He says : " Off the mouth of the Albany, for fifteen or twenty miles, the bottom is very flat and the deepest water not over twenty-five feet, slowly shoaling to twelve feet at the mouth, with numerous obstructive shoals and bars, the whole rendering it impossible for deep draft vessels to use it. The country around the mouth of the river is so low and swampy that it is hard to say where the land ends and the sea begins, and is totally unfit for the purpose of a railway terminus."[22]

Hannah bay.

The inlet named Hannah bay, which lies contiguous to Ontario territory, and receives the waters of the Harricanaw river, does not seem to offer an exception to the extraordinary shallowness which is so characteristic of the southern and western shores of James bay, and holds out no hope of affording any harbor accommodation. This is Mr. Low's description of it : " Hannah bay is so shallow that, with the exception of the river channels, it is almost completely dry at low water, and when a canoe is left by the tide the sensation experienced by its crew is anything but pleasant, as they have to debark and stand in the mud, often beyond sight of the low fringe of bushes on the high water line, awaiting the return of the water."

The waters of James bay itself are of very inconsiderable depth, and to this fact is doubtless due the shallowness of the harbors at the mouths of the rivers flowing into it. The sediment which these streams carry down to the coast being too heavy for their currents to bear out into deep water, it is being constantly deposited at their mouths and is filling up even those portions of their beds which lie immediately above. The following description by Dr. Bell will show the general character of James bay :

Dr. Bell's description of James bay.

" The southern and western shores of the bay are very low and level, and the bay itself is remarkably shallow, with the exception of a channel down its centre. For long distances we found it only possible to land from a small boat at high tide. Between high tide mark and the woods there is generally a broad, open, or marshy belt, interspersed with clumps of willow bushes and divided by muddy creeks. In some places this open border is raised above all but the highest spring tides, and constitutes a level prairie, supporting a rich growth of grasses and sedges. The marshy outline of the shore of the bay is often interrupted by points and peninsula-like islands, composed of boulders piled together in thousands, with scarcely any finer material amongst them. Owing to the numerous large rivers flowing into the southern portion of James bay, the water of this part is only brackish, and indeed in many places it is sufficiently fresh for drinking, and in some instances no taste of salt can be perceived for miles, even at a considerable distance from land. It is so shallow that a person may frequently touch the bottom with an oar, when almost out of sight of the low shore in a small boat. The constant currents kept up by the ebbing and flowing of the tides over this shallow, muddy bottom, render the water too turbid for fish to live in this part of the bay, although they are said to exist in the clearer water further out."[23]

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[22]Geological Survey Report, 1887-88, p. 22 J.

[23]Geological Survey Report, 1875-6, pp. 322-3.

NAVIGATION OF HUDSON BAY AND STRAITS.

The question of the navigation of Hudson bay is one which has been much discussed. While in the first instance it touches more closely the interests of Manitoba and the Northwest Territories, to whose products it would if practicable afford a short cut to the markets of England, it is also in some degree of importance to Ontario, in view of the fact that so large a portion of her territory is on the Hudson bay slope, and would be served by the route were it open to commerce. That some sort of navigation is practicable in Hudson bay admits of no doubt, as the vessels of the Hudson's Bay Company make their voyages from and to England unfailingly every year, bringing goods for the use of their employés and for trade with the Indians, and taking in return valuable cargoes of furs. The point in dispute is simply the period of each year during which such navigation can take place. The key to the situation is the navigability of Hudson Straits, which connect the bay with the Atlantic ocean. The surface of the bay itself is believed to be comparatively free from ice during the greater part of the year, and were there no other obstacles to contend with than the floating ice of the bay and the shore ice hemming in the ports, it is not unlikely that for at least half the year vessels could come and go with comparative immunity. The careful explorations and investigations of Lieut. Gordon, who, under instructions of the Dominion Government and accompanied by a staff of observers, made a voyage in 1884 in the Neptune and one each in 1885 and 1886 in the Alert for the express purpose of determining the period during which navigation was possible, appear to leave small room for doubt that this term in ordinary years is short, and indeed limited to about three months. In his report of 1886 that officer sums up the case in the following terms: Difficulties of navigation on Hudson bay.

"Having now made voyages on three years to Hudson straits, and having carefully examined the reports by the observers as to the formation and movements of the ice in Hudson straits, I have the honor to submit the following statement in regard to the navigation of these waters. In discussing this question I think it well to state that I am not required to report on the commercial aspect of the case and whether Hudson straits navigation can be made to pay, nor do I, in the seasonal limits given, mean to state that it is impossible for a ship occasionally to get in earlier or leave later; but, having carefully considered the subject, I give the following as the season during which navigation may in ordinary years be regarded as practicable for the purposes of commerce; not, indeed, to the cheaply built freight steamer, commonly known as the 'ocean tramp,' but to vessels of about 2,000 tons gross, fortified for meeting the ice, and of such construction as to enable them to be fair freight carriers. These vessels must be well strengthened forward, should have wooden sheating and be very full under the counter; the propeller should be of small diameter and well down in the water. I place the limit of size at about 2,000 tons, because a larger ship would be somewhat unwieldy, could not make such good way through the loose ice, and being unable to turn so sharply she would get many a blow that the smaller ship would escape. I consider that the season for the opening of navigation to such vessels as the Testimony of Lieut. Gordon.

above will on the average fall between 1st and 10th July. The position and movements of the ice I have already discussed, and need not here repeat. The closing of the season would be about the first week in October, partly on account of the descent of old ice from Fox channel into the western end of the straits, this old ice being rapidly cemented into solid floe by the formation of young ice between the pans; in such ice no ship, however powerful, could do anything to free herself. At this time, too, the days are rapidly shortening, and snowstorms are frequent, though not of great duration."[24]

The projected Hudson Bay Railway and its prospects.

The point at once suggests itself whether a route which is open for only three months of the year, and then only to specially built and equipped vessels, is likely to be of much practical utility to either Manitoba and the Northwest or to Ontario. The difficulty of carrying on a profitable trade under such onerous conditions would be very great. For instance, it would hardly be possible to move to the seaboard and transport to the English market the crops of any one harvest during the same year. This would necessitate the storing of them in elevators at the port on Hudson bay or where they were grown for at least nine months, at large expense, and with the consequent loss of interest and risk of losing a favorable market. It may be doubted whether the loss and delay to which traffic would be exposed would not bring freight charges up to at least the level of those of the more southern and longer routes. It is no doubt possible to build a railway from a point in Manitoba or the Northwest without unusual difficulty, but if the line which is at present projected is to have its terminus at the mouth of the Nelson river, the promoters will probably find that when they have reached the seaboard they have not reached a port. The same shallowness of water as exists at the mouth of the Moose characterizes the estuary of the Nelson. This river, which in point of volume may be ranked among the great rivers of the world, is very muddy, and has deposited an immense quantity of sediment at its mouth, which in consequence affords very indifferent accommodation for shipping. In Lieut. Gordon's opinion it is one of the most dangerous places in the world for ships, and besides the very large amount of dredging which would have to be done to make a channel and basin capable of holding freight-carrying vessels, there are 27 miles of channel which would require to be closely buoyed, and in addition a light-ship would be necessary for the guidance of mariners in bad weather.

Port Nelson and

There are no harbors on the south or west coast of the bay, except those formed by the mouths of the rivers, and the only other available port would be at Fort Churchill, where the river of that name falls into the bay a considerable distance north of the Nelson. The harbor here is naturally a good one, there being a spacious deep water basin large enough to accommodate a business of great magnitude, and a good mud bottom which affords an excellent holding ground, notwithstanding the rapid tides. The northerly position of Fort Churchill would however add considerably to the length of the railway, and consequently to the expense of working it. The selection of a seaport terminus on Hudson bay for a problematical railway does not appear to be a pressing matter, but if ever a line from the west reaches

Port Churchill.

[24] Report of the Hudson Bay Expedition of 1886, pp. 90-91.

tidewater on the bay it would doubtless be found that Fort Churchill has essential advantages over any other place that can be named.

FISHERIES AND FURS.

Owing to the muddy and shallow character of the water in a large portion of James bay, the fisheries there are not extensive. The lakes and rivers tributary to it from the south contain almost all the principal food fishes, such as the salmon and whitefish, salmon trout, herring, pike, etc., which provide a large proportion of the sustenance of the natives. Little has yet been done to show the extent to which fish of commercial value are to be found in Hudson bay, though both Indians and Eskimo find varieties there suitable for their own use. The fishes exported from Hudson bay and straits are salmon and salmon trout, but the codfish does not appear to go farther west than the eastern side of Ungava bay. The mouths of several rivers falling into Hudson straits are resorted to in large numbers by salmon of fine quality, in catching and exporting which a considerable business is done by the Hudson's Bay Company. For many years vessels from New England and Dundee have carried on the pursuit of whales in Hudson straits and bay. There are several varieties which are sought after, the most valuable being the one known as the "right whale," (*balaena mysticetus*), single individuals of which are worth as much as $18,000. Their value is due to the large amount of whalebone they yield, which brings a high price. The right whale is becoming very scarce, and fears are expressed lest the excessive rigor with which it has been hunted should end in exterminating it altogether. The whale most characteristic of Hudson bay is the white whale (*beluga catodon*), great numbers of which are annually taken for the sake of the oil which they produce. Seals of several kinds are found, some of them being very large in size, and all of greater or less value, but the fur seal of the Pacific ocean, the most highly-prized of the species, is absent. Other fish and mammals which possess a commercial value are the narwhal or unicorn, the porpoise, the walrus and the polar bear.

Fisheries in James and Hudson bays.

Furs are a very important product of the Hinterland, and form the principal item of export from the territory north of the height of land. The principal fur-bearing animals are the beaver, mink, marten, otter, fisher, lynx, fox, bear etc. The trapping of these creatures is done almost entirely by the Indians, who barter the spoils of their chase with the Hudson's Bay Company for clothing, food, ammunition, and other necessaries of life. Though scarcely ranking as a fur-bearing animal, the rabbit is important to the native population from its edibility and plentifulness. The caribou ranges as far south as the north shore of lake Superior, but does not occur on the swampy plains of the north, while the moose is found in considerable numbers north of lakes Huron and Nipissing and also in the neighborhood of Lake of the Woods. The height of land region and country to the south wherever settlement has not penetrated are plentifully stocked with animal life, but in the peat swamps of the northern plain the fur-bearing animals are comparatively scarce, and their rarity often inflicts severe hardships upon the natives, of whose winter

The fur trade.

food supply they constitute no small share. A single cargo of furs sent by the Hudson's Bay Company to England is sometimes worth as high as $500,000. Wild fowl, such as ducks and geese, find in these northern solitudes their favorite feeding and breeding grounds, the ponds and lakes which occur among the bogs affording them shelter inaccessible to even the Indian hunter.

POPULATION OF THE HUDSON BAY SLOPE.

Population north of the height of land.

The territory north of the height of land is peopled mainly by Indians and half-breeds, the white population being confined almost exclusively to the officers and servants of the Hudson's Bay Company. The census returns for 1891 give the population of the unorganized territory of Algoma district as 1,200, and of that of Nipissing as 910; in all 2,100; while in 1879 Mr. Borron estimated the number of inhabitants at 2,000 or 2,500, both native and European. Since that time the only appreciable increase has been due to the small settlements which have clustered round the stations of the Canadian Pacific Railway on that part of the line situated north of the divide. The Indians on and near the coast of James bay belong to the Swampy Cree tribe, and speak a dialect of the Cree language, while those living farther south are Ojibways. In the winter the Indians are scattered over the immense territory hunting and trapping, and on the approach of spring they repair to the Hudson's Bay Company posts to exchange their season's catch of furs for goods of various kinds. They usually remain in the neighborhood of the posts most of the summer, the women and children fishing, and the men either hunting or engaged in making hay, voyaging or other service for the Company. Most of the natives have European blood in their veins, the Company's officers and servants very frequently taking to themselves Indian wives. The half-breed population is consequently almost wholly of Scotch, English or Scandinavian extraction, there being very few French half-breeds in the territory. Both natives and half-breeds are spoken of in terms of praise by those familiar with them, the influence of the Hudson's Bay Company officials having on the whole had an educative and beneficial effect upon the Indian character. They are industrious, honest, peaceable and intelligent. Their mode of life is a hard one, the scarcity of game in some seasons reducing them to threatened and sometimes to actual starvation. The Indian title has not yet been wholly extinguished in this region, no treaties having been made to acquire the aboriginal rights. As a consequence the reserve system does not prevail, and the Indians are free to roam about as they may wish.

Government by the Hudson's Bay Company.

So far the whole work of governing the region north of the height of land has been practically in the hands of the Hudson's Bay Company. Neither the Provincial nor the Dominion Government provides schools, administers justice, or carries the mails. What means of education exist are due to disinterested philanthropy, chiefly that of the Church Missionary Society of London, England.[25] Otherwise the most elementary functions of government are discharged by the Hudson's Bay Company, whose rule has on the

[25] A small grant ($100) is now made annually by the Education Department, Toronto, to the Bishop of Moosonee, in aid of the school at Moose Factory.

whole been a beneficent one. On a small scale the Company has for many years played a part similar to that enacted by the East India Company down to 1858, but with the advantage of dealing only with white men wholly dependent and with natives almost wholly dependent upon the Company for supplies and support. Its policy has been here as in other parts of the continent to refrain from interfering in quarrels among the natives, and while carefully guarding the interests of the Company and making as large a profit as possible out of its trade, to deal justly and equably with all. The limited commerce of the territory, which is wholly with England, is altogether in the hands of the Company, and this fact is of itself almost sufficient to confer upon it the commanding influence which it enjoys.

Drawbacks of life at James bay.

The few whites of this northern region lead a life of of isolation and exile, and have very few points of interest in common with the other inhabitants of the province. There are only three mails a year to Moose Factory, and the inhabitants of that distant post and adjacent territory are chronically three or four months behind the times so far as the outside world is concerned. The chief connecting link between them and the Dominion is the custom house officer, who levies toll on the goods imported from England at exactly the same rates as are collected at Montreal or Toronto. For the year ending 30th June, 1892, there was collected at Moose Factory the sum of $14,551.01 ; for the year ending 30th June, 1893, $10,567.01, and for the year ending 30th June, 1894, 9,150.70, a total in three years of $34,268.72. The average yearly collection is $11,422.90, the immediate effect of which of course is to add the amount of duty to the selling price of the articles imported, and thus to increase by a considerable percentage the cost of living not only of the Hudson's Bay Company's servants, but also of the native population, who can ill afford to bear the burden. The spiritual welfare of the people, both Indian and white, is looked after by the Church of England and the Roman Catholic Church, principally the former, to which many of the Indians belong. The bishop of Moosonee, Rev. Dr. Newnham, has his official seat at Moose Factory, and his diocese extends inland on all sides of Hudson Bay covering an area of about 600,000 square miles.

Future of the Hinterland.

Prospects of northern Ontario.

To foretell the future of the great Hinterland of Ontario is an impossible task. Any prophecy would doubtless be discredited by the issue of events. It is easy to underestimate the part which it is destined to play in the history of our province, and it is also possible to overrate it. We might entertain too gloomy a view if we allowed our minds to dwell upon the countless rocky ridges and great stretches of peat morass which it undeniably contains ; and on the other hand our imagination might take fire too readily if we contemplated exclusively its vast extent, its fertile belts, and its wealth of minerals and timber. Settlement is beginning to take place on a considerable scale in some of the areas of good land, which will undoubtedly become the homes of a large agricultural population, while great tracts will wait long before the covetous eyes of land-seekers will find in them much attraction. But the time will doubtless come when the pressure of population on the means of subsis-

tence will force all available land into cultivation; and when that period arrives there is no reason why the now neglected areas of northern Ontario should not sustain a hardy people like the Swedes and Norwegians, or other north Europeans, in comfort and plenty. Railway communication between the cultivable districts and older Ontario is the first step in the development of the Hinterland. Railways have been projected into the fertile areas of both the west and the east. The Ontario and Rainy River railway will, when completed, run from some point on the Port Arthur, Duluth and Western railway to the rich agricultural belt extending from Rainy lake to Lake of the Woods, and is intended eventually to reach the latter place. The Nipissing and James Bay railway which is to start at North Bay and terminate at James Bay will in its southerly portion run through a district containing a very large quantity of pine timber, and when it strikes the shore of lake Temiscaming will afford access to the great tract of fine soil which lies to the west and north of that lake. It seems likely that this district will be one of the first to be opened up and settled, and a railway into it from older Ontario would secure to the province the advantage of the trade which would doubtless be developed there upon its dormant resources falling into the hands of energy and enterprise.

A field for expansion.

It is satisfactory to know that Ontario has room for expansion within her own borders, and that her sons do not require to leave their native province to find as good an opportunity for acquiring a competence as is offered anywhere else to industry and thrift. It is coming to be known that in northern and northwestern Ontario the soil is as fertile, the climate as good, and the general conditions as favorable, as in either the provinces of the Northwest or any of the states of the Union. Railway communication, which in some of the fertile areas is wanting, bids fair to be supplied. The Ontario farmer or farmer's son who wishes to better his lot will find in Ontario the schools, the churches, the municipal and parliamentary institutions, the society, the respect for law and order, in a word all the conditions to which he has been accustomed, and it is therefore possible to begin life in a new district without experiencing a violent break in either habits or surroundings. All of these conditions may not be present at the start, but the increase of settlement will bring about their development and steady growth.

Stages of growth in a community.

The capacity for self-government which characterizes the English-speaking race is nowhere more noticeable than in Ontario, and nowhere have public institutions been moulded so as to give that capacity more perfect freedom of action. The township is the unit of municipal government, and it is interesting to watch the evolution of a township from a mere geographical expression to an active member of the public community, fully equipped for the direction of those matters of local moment so important to its inhabitants in the earlier as well as in the later stages of its history. First, the Department of Crown Lands surveys off into farm lots of 100, 200 or 320 acres each a block of wild land, and sooner or later opens it for settlement. If the soil is fertile and the locality inviting, it will probably be found that hardy bushmen of the pioneer class have anticipated the action of the Department, and have "squatted" upon lands which took their fancy without waiting for the forma-

lity of their being placed upon the market. Settlers find their way in, are suited with the land, write their friends to come and join them, and so the population slowly increases. Roads are as essential to the growth of the small community as arteries are to the human body, and in the early stages of its career the Department of Crown Lands comes to its aid with grants to build needed lines of communication, to the construction of which the settlers themselves frequently contribute. There is provision in the law by which even in this inchoate state of the community formal steps may be taken to levy upon all landholders an equal rate towards the expenses of building these roads. The next step is organization, by which the full status of a self-governing township, with reeve and council, is attained. Usually, this dignity is assumed in conjunction with one or more neighboring townships, which thus share the necessary expense of incorporation and administration, the partnership being maintained until each member of it is able to stand alone. The council annually elected by the people has full control of roads, bridges and the many smaller matters which enter into the corporate life of the community, and is endowed with extensive powers of taxation to carry its determinations into effect.

Municipal and educational institutions.

Concurrently with the development of the municipality goes on the growth of educational institutions. Even before the township is organized, school sections may be set apart on petition of the heads of five families resident therein. The township council is charged with the duty of dividing the township into sections for school purposes, but these sections when formed are practically autonomous in the administration of their affairs, subject of course to the general educational law of the province. The ratepayers therein elect a board of trustees who build the schoolhouse, engage the teacher, and determine the amount to be levied by the township council on the ratepayers of their section for school purposes.

It is thus seen that the settlers in the new districts of the province are in possession of nearly the same powers and privileges as regards the important matters of municipal government and education, so far as the circumstances will admit, as the people of the older counties are. Nor are they deprived of a voice in the election of members of the local and federal parliaments. On the contrary, elaborate precautions are taken and considerable expense incurred to give them that share in the free choice of a representative which is the birthright of every citizen.

The settlement of Ontario has so far been very largely a spontaneous process, and has been carried on without many of those attempts at wholesale colonization which have been tried in other provinces and countries, often with very doubtful results. The merits of the country, and not undue puffing or injudicious praise, have attracted a class of settlers who with their descendants form the backbone of the community, and it is to a continuation of the process which has been so successful in the past that we may look for the occupation and peopling of the Hinterland. Growth so made may be slow, but it will be healthy and enduring, and there will be no discontented settlers, misled by false hopes and disappointed because the reality has fallen short of

their expectations, to belittle the country and invoke wrath upon the heads of those who deceived them. With the advantages of fertile soil, good markets, abundant timber, temperate climate and free institutions, it would seem that the northern regions of Ontario must at no distant date attract a much greater share of attention than they have hitherto done. Looking into the future one may descry the soil, the timber, the minerals and the fisheries of this great wild land affording the means of livelihood to a hardy race whose frames will be as robust, and whose love of liberty will be as great, as those of a nation nurtured in a northern clime are wont to be.

T. W. G.

SECTION IV.

CALCIUM CARBIDE AND ACETYLENE GAS.

A subject of large and ever-growing interest to the people of Ontario is the supply of materials for fuel and light. For fuel we have been dependent upon the wood of our forests, and for light on the fat of animals or the gas and oil of our rocks. There is no other natural source provided in the country itself, and as the timber area diminishes with the process of settlement we are being forced to look elsewhere for the materials of supply. Coal furnishes us with both fuel and light, and almost all that we consume comes to us from the mines of Pennsylvania and Ohio. Petroleum oil is also imported from the same states to some extent; but with the high protective duties the home producers are enabled to control the market almost wholly, in spite of the limited production of the Ontario oil fields.

Natural sources of supply for fuel and light.

Twenty-five years ago, in the fiscal year 1868-9, the import of crude petroleum and its products into Ontario was 47,054 gallons, valued at $12,053, upon which the charge for customs duty was $6,214. In 1893-4 the total import of crude and refined oils into the province was 2,388,402 gallons, valued at $132,159, and the duty levied was $169,812. In the former year the average rate of duty was 13 cents per gallon specific or 51½ per cent. ad valorem, and in the latter year 7 cents specific or 128 per cent. ad valorem; yet the average value per gallon, calculated on the entry valuation plus the duty, fell from 39 cents in 1868-9 to 12½ cents in 1893-4. Oil for light, as these figures show, is not a very important item in the foreign trade of the province; we would hardly miss it if excluded altogether, except perhaps for the higher price which monopoly might enable the home producers to fix and maintain. It is otherwise however with coal, which we cannot produce at home for the sufficient reason that long before the carboniferous age of the earth, as well as during and after that age, our province was dry land, so that the coal measures are wholly wanting; or, if formed, that they were subsequently broken up and swept away by the action of denuding agencies. The coal fields of Nova Scotia, of the Northwest Territories and of British Columbia might supply us if Nature had not interposed the barrier of distance; and so, notwithstanding barriers of governmental invention, we obtain what is demanded by our necessities from Ohio and Pennsylvania. In 1868-9 the total quantity brought into Ontario for consumption was 212,305 tons of coal and coke, valued at $680,897. Twenty-five years later, in 1893-4, the quantity was 2,441,800 tons, valued at $7,500,558, but to which should be added $798,322 paid for customs duty, making the total $8,298,880. This includes coal, coke and dust of the hard and soft varieties. Now it must be borne in mind that very little of this article of fuel is used in the rural districts, where wood is still more or less abundant. It is all or nearly all consumed in the cities, towns and

Importations of petroleum and coal.

Comparative per capita consumption of coal in the province.

villages of the province, excepting what is required by the railways and steamboats; and therefore in computing averages per capita of population the inhabitants of the rural districts are properly excluded. In 1868-9 the average of the province was only two-thirds of one ton per capita, valued at \$2.25. In 1893-4 it was $2\frac{2}{3}$ tons per capita, valued at \$9.15.[1] These facts illustrate the changed conditions of our country in the short period of twenty-five years, due to the cutting off of our natural supplies of fuel, and they fully justify the interest which this Bureau has taken from the first in the question of fuel supply; there is no other of greater moment before us in Ontario, as regards the economies, the comforts and the very existence of our people. It is not merely that we should aim to be independent of foreign states for the necessaries of life, of which in our climate fuel and light are among the chief, but also that the necessaries should be provided cheaply and in abundance.

A process for converting lime and carbon into material for light and fuel.

The most promising discovery in recent years for the supply of light and fuel has come into prominence in the scientific world during the last few months, viz., a process for the economic production of calcium carbide and acetylene gas. It is the invention, too, of a young Canadian, and if only the half of the expectations concerning it are realized we shall be far on the way to a satisfactory solution of the fuel and light problems. The papers which follow give interesting accounts of the discovery, as well as of its uses; and although it is likely that further investigations and experiments will add to the value of the invention, there does not appear at present to be substantial reason for doubting that it can be practically and successfully applied to serve in a large degree the purposes for which it is intended.

Willson's claim of discovery.

It is not pretended by the inventor, Thomas Leopold Willson,[2] that he discovered acetylene gas, or the properties of the carbides. His claim is that he has found a process for the commercial production of calcium carbide,

[1]In computing these estimates the urban population of the province is taken at 335,745 in 1868-9, and at 906,262 in 1893-4.

[2] Thomas Leopold Willson was born at or near the village of Princeton, in the county of Oxford, in 1860. His father, the late Thomas Whitehead Willson, was a son of Hon. John Willson, a gentleman who figured conspicuously in the Legislature of Upper Canada in the early part of the century. In the Documentary History of Upper Canada (vol. I., p. 101) Dr. Hodgins says: "Mr. John Willson was elected to represent the west riding of the county of York [Halton] in 1809 and 1813, and the county of Wentworth in 1820, 1825, 1829 and 1831. He became Speaker of the House of Assembly in 1825." In the Legislature he took a leading part, according to Dr. Hodgins, in carrying through a measure for establishing the public school system of the province in 1816 (pp. 94-100), but his name is not mentioned in connection with the Act of 1824 for the permanency and extension of the previous Acts (p. 197). The Hamilton Spectator of May 29, 1860, says the Act of 1816 was drafted by Mr. Willson and passed into law mainly through his influence, and that he afterwards, "when it was about to expire in 1824, introduced and carried an Act to make it perpetual." "Thus," the Spectator says, "was laid the foundation of that admirable system of education which has since the union of the provinces placed the inestimable blessing of a generous share of education within the power of every person brought up in the province." This Hon. John Willson was born in New Jersey in the year of American Independence, he came with his guardian to live at Niagara the year before Upper Canada was established as a province, and settled upon a farm on the shore of lake Ontario, in Saltfleet, Wentworth county, in 1797, where he lived until his death in 1860. The grandson is proving himself worthy of the stock of this pioneer, and of the school system which he did so much to organize and establish. From 1872 to 1881 (as I learn from Mr. C. A. Abraham of the Woodstock Sentinel Review) he resided in Hamilton and was trained in the excellent schools of that city. From an early age he showed a marked fondness for chemical and electrical experiments, and at nineteen he produced the first electric light exhibited in the city, with the help of Senator Sanford and Mr. Hood of the Royal Hotel as business partners. But feeling the necessity of securing a wider field for his work, he went in 1881 to New York, and there unaided by anything but his personal ability, determination and integrity he has won success and fame.

using for materials common lime and carbon in any form—hard or soft coal, coal dust, charcoal, petroleum, tar or peat—and treating them in an electric furnace ; and he is confident that where electricity can be generated with water power the cost of manufacturing calcium carbide brings it easily into competition with other materials of fuel and light. A plant erected near a great water power like Niagara Falls, Mr. Willson maintains, may supply the continent at a figure with which coal gas cannot compete ; for there the power is ample for almost any conceivable requirement, alongside a mountain of limestone, while coal dust or culm may be had for little more than the cost of haulage from the mines of Pennsylvania and Ohio.

Steps taken to utilize the invention in Great Britain,

The attention of capitalists has already been drawn to the new discovery. A leading manufacturer of Leeds, Eng., has been negotiating for the right to use the patent in that country, and three distinguished scientists have been employed by him to enquire into and report upon the merits of the invention. One of these is Professor Lewes, whose report is substantially the paper read before the Society of Arts. In the United States a plant for the production of calcium carbide is expected to be ready for operation shortly, and arrangements are being made to procure electrical energy on both sides of the Niagara river, from the strong company which controls the power franchises at the Falls. The Canadian General Electric Company has acquired the patent for Canada, and a plant is now in course of construction at their shops in Peterborough. As prudent men, the directors of the company will begin upon a moderate scale, and if it is shown that calcium carbide can be produced economically and that there is reasonable assurance of a market being found for it in the country, they will no doubt prepare to meet the demand as fast as it grows.

the United States

and Canada.

Various estimates of the value of the invention ;

Like every other invention, the value of Mr. Willson's process is variously estimated. In the opinion of some authorities the cost bars it from competing with any hope of success with other and better known processes for manufacturing materials of fuel and light, not to speak of the bad odor of acetylene and its dangerous explosive qualities. In the opinion of others the question of cost has already been decided satisfactorily. And as for the bad odor of the gas, they say that this is one of its good qualities, since it facilitates the discovery of a leak ; in burning, it gives off no odor, all or almost all of the gas being consumed in the flame, which is not the case with coal or water gas. And as regards the risk of explosion, they say that this is a matter of proper management. There seems to be no doubt however that the utility of acetylene as an enricher of common gas, which was a merit at first claimed for it, has no substantial value, because other methods are found to give cheaper and equally good results.

but demonstration will come with the furnace test.

The papers which follow present the subject fully enough for a fair understanding of it, and most of the criticisms appear to have been met as completely as the criticisms of any new discovery can be met until demonstration comes in the "furnace test." Bessemer was ignored and ridiculed in a more humiliating way by eminent men than Willson has been ; and if that instance has any value now, it is that we should wait patiently for the demonstration.

THE COMMERCIAL SYNTHESIS OF ILLUMINATING HYDRO-CARBONS.[3]

By Professor Vivian B. Lewes.

Analysis and synthesis.

The two methods most used in chemical science for tracing the changes taking place in matter, and determining the composition of bodies, are, firstly, the breaking up of compounds into their ultimate constituents, a process which is called 'analysis'; and, secondly, the building up of the compound from the elementary matter which forms it, a process to which the name of 'synthesis' has been given.

Elements of chalk.

If we take chalk and heat it in the limekiln, or in the chemist's crucible, a heavy, colorless gas called carbon dioxide escapes from it, and leaves behind a substance which we know as quicklime. If now this quicklime be further acted upon by chemical methods, it can be shown to contain the metal calcium and the elementary gas oxygen, whilst the carbon dioxide when collected can be decomposed into the elements carbon and oxygen, and by such a series of operations as this we might perform the analysis of chalk.

If now we start with the metal calcium, with carbon, and with oxygen, it is perfectly simple to reverse the operation, and rebuild the chalk molecules from these elementary forms of matter; by burning the carbon and calcium respectively in oxygen, we obtain the quicklime and the carbon dioxide, and by bringing these substances together in the presence of moisture, chalk or calcic carbonate is once more formed, and we have synthetically built up the chalk from its constituents.

Forming organic products from inorganic materials.

By such simple methods as these most inorganic compounds can be synthetically produced from elementary matter, but in the so-called organic chemistry it is not so easy to employ such constructive methods for the formation of compounds. Up to the end of the first quarter of this century it was supposed that organic bodies were only produced as the result of animal and vegetable life, and that their formation was due to the so-called 'vital force' which was credited with governing all changes taking place in living organisms.

In 1828 Wohler showed that urea could be formed from cyanate of ammonium, whilst later on Fownes made cyanogen by the direct combination of carbon and nitrogen, these two discoveries taken together proving the possibility of forming an organic product from inorganic materials; and after this point had been reached, and the possibility of applying synthetic methods to the production of organic bodies had been demonstrated, compound after compound was built up without the aid of either vegetable or animal life, and the barrier between inorganic and organic chemistry finally broken down. Cases however in which such methods could be commercially successful were few and far between, as in most cases the processes which had to be adopted were costly and laborious.

[3]A paper read before the Society of Arts of London, England, January 16th, 1895, and printed in the Journal of the Society, January 18th.

Acetylene Gas.

In all the phenomena of ordinary combustion which we employ to provide us with heat and light, there are no compounds of greater interest than the class of organic bodies which, being formed of carbon and hydrogen in various proportions, have been termed hydrocarbons, and it is to this class of bodies that all the gases which can be used as ordinary illuminants owe their luminosity. Amongst the hydrocarbons the simplest compound is acetylene, in which two atoms of carbon are united with two atoms of hydrogen; and it has long been known that, if a stream of hydrogen is passed through a globe in which the voltaic arc is produced between carbon points from a sufficiently powerful current, this gas is produced in minute quantities. It can also be formed in small quantities by the decomposition of carbon tetrachloride in the presence of hydrogen by the induction spark, whilst it is produced during processes of checked combustion in hydrocarbon flames.

The hydrocarbons

The direct combination of carbon and hydrogen in the electric arc is a true case of synthesis, and if we could form acetylene in this way in sufficiently large quantities, it would be perfectly easy to build up from the acetylene the whole of the other hydrocarbons which can be used for illuminating purposes. For instance, if acetylene be passed through a tube heated to just visible redness, it is rapidly and readily converted into benzol; at a higher temperature naphthalene is produced, whilst by the action of nascent hydrogen on acetylene ethylene and ethane can be built up. From the benzol we readily derive aniline and the whole of that magnificent series of coloring matters which have gladdened the heart of the fair portion of the community during the past five and twenty years, whilst the ethylene produced from acetylene can be readily converted into ethyl alcohol by consecutively treating it with sulphuric acid and water, and from the alcohol again an enormous number of other organic substances can be produced. Thus acetylene can without exaggeration be looked upon as one of the great keystones of the organic edifice, and, given a cheap and easy method of preparing it, it is hardly possible to foresee the results which will be ultimately produced.

and their derivatives.

From acetylene we can produce all those bodies which we are accustomed to look upon as the most important ones in our coal-gas, and which up to the present time have never been produced from anything but coal, hydrocarbon oils, or other organic matter undergoing destructive distillation; but it has often occurred to those of us who are interested in the manufacture of illuminating gas that as the supply of coal gets smaller, and as oil in time begins to share the same fate, some new sources for our illuminants and our fuels must be sought; and in my mind at any rate the synthetic production of hydrocarbons has long been a day dream, which I however never expected to see possible on a commercial scale.

Not only was the synthetic production of acetylene in the electric arc well known, but ever since water-gas has been introduced small traces of acetylene and methane have been found in it under conditions which render it impossible that they should have been produced from any compound present in the incandescent fuel. They must therefore have been due to the direct combination

of carbon and hydrogen, but these traces only occurred in quantities so small as rarely to amount to one per cent., and it was manifest that the production of the compounds could not take place in large quantities under influences which would immediately tend to decompose them.

History of the discovery of economic production

In 1836 it was found that when making potassium, by distillation from potassic carbonate and carbon, small quantities of a bye-product consisting of a compound of potassium and carbon were produced, and that this was decomposed by water with liberation of acetylene; whilst Wohler by fusing an alloy of zinc and calcium with carbon made calcic carbide, and used it as a source from which to obtain acetylene by the action of water.

Nothing more was done until 1892, when Macquenne prepared barium carbide by heating at a high temperature a mixture of barium carbonate, powdered magnesium and charcoal, the resulting mass evolving acetylene when treated with water; whilst still later Travers made calcic carbide by heating together calcic chloride, carbon and sodium. None of these processes however gave any commercial promise, as the costly nature of the potassium, sodium, magnesium or zinc-calcium alloy, which had to be used, made the acetylene produced from the carbide too expensive.

It is now some 25 years ago since I listened to one of the Friday evening lectures at the Royal Institution, given by Mr. Greville Williams, and in the same way that the thread of some melody lingers in one's mind, so has the concluding sentence of that lecture constantly recurred with ever-increasing force: "The impossible is a horizon which recedes as we advance; and the terra incognita of to-day will to-morrow be boldly mapped upon every schoolboy's chart." The haunting dream of the possibility of synthesizing hydrocarbons commercially has, with the onward march of science, to-day become an accomplished fact.

As is so usual in the history of discovery, the factor which has endowed us with the power of doing this was not the outcome of an elaborate research, having this discovery for its ultimate goal, but was found by chance during the search for another object.

by Willson in the electric furnace.

Whilst working with an electric furnace, and endeavoring by its aid to form an alloy of calcium from some of its compounds, Mr. T. L. Willson noticed that a mixture containing lime and powdered anthracite, under the influence of the temperature of the arc, fused down to a heavy semi-metallic mass which having been examined and found not te be the substance sought was thrown into a bucket containing water, with the result that violent effervescence of the water marked the rapid evolution of a gas, the overwhelming odor of which enforced attention to its presence, and which on the application of a light burnt with a smoky but luminous flame.

A result of double decomposition.

Investigation into the cause of this phenomenon soon showed that in a properly constructed electric furnace, finely ground up chalk or lime, mixed with powdered carbon in any form, whether it were charcoal, anthracite, coke, coal or graphite, can be fused with the formation of the compound known as calcic carbide, containing 40 parts by weight of the element calcium, the basis of lime, and 24 parts by weight of carbon, and that on the addition to this of water a double decomposition takes place, the oxygen of the water combining

with the calcium of the calcic carbide to form calcic oxide or lime, whilst the hydrogen unites with the carbon of the calcic carbide to form acetylene, the cost of the gas so produced bringing it not only within the range of commercial possibilities for use per se, but also the building up from it of a host of other compounds, whilst the production of the calcic carbide from chalk and from any form of carbon renders us practically independent of coal and oil, and places in our hands the prime factor by which Nature in all probability produces those great underground storehouses of liquid fuel upon which the world is so largely drawing to-day.

Economic Effect of the Discovery.

Wonderfully and intensely interesting as is the train of thought opened up by the discovery of this substance and its commercial production, the object I have in view this evening is not to discuss theoretic possibilities, but to show you the important effect which it will have in the direction of our great gas industry, and the phase of this which I wish to deal with specially is the value of acetylene, either for producing per se an enormously high illuminating effect, or for the enrichment of low grade coal-gas. [4]

Value of acetylene as an illuminant.

When the calcic carbide is placed in a glass flask, and water allowed to slowly drip upon it from a dropping tube, the decomposition at once commences with considerable rapidity, and the acetylene pours off in a continuous stream; as the decomposition continues, the solid mass in the flask swells up, and is eventually converted into a mass of slaked lime.

Changes of decomposition.

Calcic carbide is a dark gray substance, having a specific gravity of 2 262, and when pure a pound of it will yield on decomposition 5 3 cubic feet of acetylene. Unless however it is quite fresh, or means have been taken to carefully protect it from air, the outer surface gets slightly acted upon by atmospheric moisture, so that in practice the yield would not exceed five cubic feet. The density and hardness of the mass however protect it to a great extent from atmospheric action, so that in lumps it does not deteriorate as fast as would be expected, but in the powdered condition it is rapidly acted upon.

For commercial purposes the carbide will be cast direct from the electric furnace into rods or cylindrical cartridges, which, when 12 inches long and $1\frac{1}{4}$ inches in diameter, will weigh one pound, and will give five cubic feet of gas.

The acetylene so made when analyzed by absortion with bromine, the analysis being also checked by determining the amount present by precipitation of silver acetylide, gives 98 per cent. of acetylene and 2 per cent. of air, and traces of sulphuretted hydrogen, the presence of this impurity being due to traces of sulphate of lime—gypsum—in the chalk used for making it, and to pyrites in the coal employed.

Acetylene is a clear, colorless gas with an intensely penetrating odor which somewhat resembles garlic, its strong smell being a very great safeguard in its use, as the smallest leakage would be at once detected; indeed

Safe properties of the gas.

[4] Experiments on the enrichment value of the gas subsequently made by Professor Lewes have convinced him that "acetylene will be of no practical use to the gas manufacturer as an enrichment of gas in bulk, as it can never hope to compete in price with oil gas as made by the Peebles process."

so pungent is this odor that it would be practically impossible to go into a room which contained any dangerous quantity of the gas.

This is an important point to remember, as the researches of Bistrow and Liebreich show that the gas is poisonous, combining with the hæmoglobin of the blood to form a compound similar to that produced by carbon monoxide, whilst the great danger of the latter gas is that having no smell its presence is not detected until symptoms of poisoning begin to show themselves, so that no fear need be apprehended of danger from this source with acetylene.

Its solubility,

Acetylene is soluble in water and most other liquids, and at ordinary temperature and pressure—60° Fahr. and 30 inches of mercury—10 volumes of water will absorb 11 volumes of the gas, but as soon as the gas is dissolved the water being saturated takes up no more. Water already saturated with coal-gas does not take up acetylene quite so readily, whilst the gas is practically insoluble in saturated brine—100 volumes of a saturated salt solution only dissolving 5 volumes of the gas. The gas is far more soluble in alcohol, which at normal temperature and pressure takes up six times its own volume of the acetylene, whilst 10 volumes of paraffin under the same conditions will absorb 26 volumes of the gas. It is a heavy gas, having a specific gravity of 0.91.

and burning qualities.

When a light is applied to acetylene it burns with a luminous and intensely smoky flame, and when a mixture of one volume of acetylene with one volume of air is ignited in a cylinder a dull red flame runs down the cylinder, leaving behind a mass of soot and throwing out a dense black smoke. When acetylene is mixed with 1.25 times its own volume of air the mixture begins to be slightly explosive, the explosive violence increasing until it reaches a maximum with about twelve times its volume of air, and gradually decreases in violence until with a mixture of one volume of acetylene to twenty of air it ceases to be explosive.

Behavior under pressure.

The gas can be condensed to a liquid by pressure, Ansell finding that it liquefied at a pressure of 21.5 atmospheres, at a temperature of 0° C., whilst Cailletet found that at 1° C. it required a pressure of 48 atmospheres, the first-named pressure being probably the correct one. The liquid so produced is mobile and highly refractive, and when sprayed into air the conversion of the liquid into the gaseous condition absorbs so much heat that some of the escaping liquid is converted into a snow-like solid, which catches fire on applying a light to it, and burns until the solid is all converted into gas and is consumed.

The cause of luminosity in the hydrocarbons.

In my researches upon the luminosity of flame I have shown that all the hydrocarbons present in coal-gas and other luminous flames are converted by the baking action taking place in the inner non-luminous zone of the flame into acetylene before any luminosity is produced, and that it is the acetylene which by its rapid decomposition at 1,200°C. provides the luminous flame with those carbon particles, which, being heated to incandescence by various causes, endow the flame with the power of emitting light. The acetylene, being in this way proved to be the cause of luminosity, one would expect that in this gas we have the most powerful of the gaseous hydrocarbon illuminants; and experiment at once shows that this is the case.

Owing to its intense richness it can only be consumed in small flat-flame burners, but under these conditions emits a light greater than that given by any other known gas, its illuminating value calculated to a consumption of 5 cubic feet an hour being no less than 240 candles.

Illuminating value of acetylene.

Illuminating Power of Hydrocarbons for a Consumption of 5 cubic feet of Gas.

	Candles.
Methane	5.2
Ethane	35.7
Propane	56 7
Eythelene	70.0
Butylene	123.0
Acetylene	240.0

Commercial Aspect of the Problem.

Having arrived at this startling result it will be as well to at once turn to the commercial aspect of the problem, as it is upon this that the utilization of this magnificent illuminant is entirely dependent. At the present time private information from America shows that calcic carbide can be produced at a little under £4 a ton, and the beautifully pure lime obtained by the decomposition would be worth to the gas manager at least 10s. a ton; and as a ton of the carbide will give rather more than 1¼ tons of quicklime or 1¾ tons of slaked lime, £3 10s. may be taken as the cost of the acetylene produced from a ton of the material, and will leave a margin for handling. A ton of the carbide will yield in practical working 11,000 cubic feet of acetylene, which will bring the cost of the gas out at 6s. 4½d. per 1,000.

Data of cost of production.

The cheapest and best enrichment process known at the present time is that introduced by Mr. Young, and which has been adopted at a number of gas works in Scotland and the north of England. In this process, by special methods of retorting, oils are decomposed to yield a rich gas, which in the photometer and burnt in suitable burners per se gives an illuminating value of about 60 candles, but for which an enrichment value of 96 candles is claimed. [See footnote p. 145].

Enrichment values

I am desirous of understating rather than overstating the powers of the acetylene, so that instead of taking enrichment values for it which might be questioned, I prefer to simply take the illuminating power of the gas when burnt, per se, and the light measured in the photometer, which as before stated is 240 candles, whilst for the same reason we will take the claimed enrichment value of the Young gas, instead of its photometric value.

of oil gas

An extended experience gained with the Young process, as used at St. Helen's for the enrichment of coal-gas, shows that the cost may be taken at 3s. 4d. per 1,000 cubic feet. If now we compare this with the acetylene at 6s. 4½d. per 1,000, we find that the 240-candle gas at this price would be equal to Young gas at 2s. 6½d. Moreover the Young plant to work a ton of oil per diem costs—according to the experience at Peebles—£1,500, and generates 22,000 cubic feet a day, the retorts for this purpose occuyping a very considerable space; whilst to make the same volume of acetylene two tons of material would have to be handled, and the whole operation could easily be carried out in one small egg-ended boiler, fitted with an automatic water feed

and acetylene compared.

and automatic gas delivery valve to outlet of the main for the holder, so that the enriching gas could be added pro rata to the gas as it left the works in order to bring it up to any required strength, in the same way as is done with the Maxim-Clarke enrichment, and all the troubles of stratification in the holder would be done away with. For the first few hours the water in the consumers' meters would absorb small quantities of the acetylene, but quickly becoming saturated no further absorption would take place.

Minimizing the risk of explosion.

It is well known that acetylene forms two compounds with ammoniacal solutions of the metals silver and copper, and both of these compounds when dry can be readily exploded by percussion, friction or heat. In the early days of gas supply, copper pipes were used in New York, and Torrey in 1839 found in them a brown scaley deposit which exploded when struck or heated to 200° C., and which was in all probability acetylide of copper.

An extended series of experiments on this point show that when metals are kept in the gas, even if moisture be present, no action takes place unless water condenses on the metal when tarnishing with silver and copper, and to a less degree with brass, commences, and under these conditions an acetylide of mercury can also be formed, but the other metals remain unacted upon. If therefore iron, tin, lead, or compo pipes be used for the gas supply, no precautions are necessary. Copper and brass tubes must either be coated inside with some varnish not acted upon by the acetylene, or tin lined.

In America, which was the birthplace of this method of making calcic carbide, the acetylene is mixed with an equal volume of air and the mixture burnt at small slit burners; but I confess to a grave mistrust of this method of using the gas, as the margin of safety in the amount of air required to convert the mixture into an explosive is so small that the danger of exceeding it on any large scale must be very great, as any mistake or alteration in the mixing apparatus used for this purpose might easily bring the percentage of air up to the explosive limit, whilst the diluting action of the nitrogen of the air reduces the illuminating value of the acetylene present from 240 candles to 130.

Scope and Possibilities of the Discovery.

Storage of acetylene in the liquefied state.

The possibility of liquefying acetylene by pressures about those at which liquid carbon dioxide is produced so largely enables enormous volumes of this gas to be compressed into the liquid state in small wrought iron or steel cylinders, and in this condition by means of suitable reducing valves and burners of the right construction it may be stored and burnt. Used in this way, it will be of the greatest possible value for floating buoys, and the small cylinders can also be arranged in the form of portable lamps, whilst for use in the country, where no gas is available, a large cylinder of the liquid gas placed in an outhouse would supply a country house with light for a very long period; and there is no doubt that there is a very great field for it in this direction, as by utilizing suitable burners a consumption of half a cubic foot an hour will give a light equal to from 20 to 25 candles.

Perhaps the most valuable suggestion which has been made with regard to the utilization of this remarkable method of making acetylene is, that advantage should be taken of the method of preparation to utilize the

body of portable lamps for dining and drawing-rooms in places where no gas supply exists. To do this a strong steel cylinder, 4 inches in diameter and 16 inches in length, is fitted with an opening in the top of such size that a pound cartridge, or stick of the calcic carbide, can be passed through it. The cylinder has a second opening at the bottom, closed by a screw for cleaning out the lime left by the decomposition. The right proportion of water is put into the cylinder, and the stick of carbide coated with a slowly soluble glaze is inserted and the head of the lamp screwed on. The head contains a double reducing pressure valve, which brings down the pressure existing in the cylinder to that necessary for the proper consumption of the gas, it also being fitted with a valve. As the glaze dissolves from the surface of the stick of carbide acetylene is generated, and the five cubic feet are compressed by their own pressure, the cylinder being placed in a vessel of cold water whilst the gas is generating, and the gas can then be burned from a suitable jet at the rate of half a cubic foot per hour, which will give a light of over 20 candles for something like 10 hours. When the gas is all burnt out from the cylinder the top of the lamp is screwed off, the bottom plug also removed, and the lime washed out from the interior of the cylinder by a rapid stream of water. The cylinder is then recharged as before. Used in this way also this gas would rapidly replace oil gas for railway lighting, as the fittings at present in use for the Pope and Pintsch systems would answer perfectly well for the purpose of using acetylene, the only difference being that the cylinder placed below the carriage, which under the present conditions is filled with compressed oil gas, would be utilized not only as a storing but as a generating vessel for the acetylene, the highly expensive oil gas manufacturing and pumping plant being done away with, and a magnificent illumination ensured in the carriage.

A simple method of using the gas in houses

and in railway coaches.

Of late years an idea has been slowly permeating the minds of some gas managers in this country that it might be well to adopt a dual gas supply, one for fuel purposes, which would consist of a poor coal-gas of about 12 candles, whilst the gas for illuminating purposes would be of about 20 candles; and in one town at least it has been proposed, and I believe carried out, that a supply of poor quality coal-gas should be sent out during the day, when the maximum consumption is for heating purposes, and a richer gas at night for illuminating purposes, utilizing the same mains for both. Although this is possible in a small town where the area to be supplied is not large, it would be impossible in a big town where many miles of huge mains have to be travelled before certain districts are reached, and the cost of a double set of mains would render a dual supply an impossibility.

The use of acetylene would render it possible for the gas company to send out a 12-candle gas for heating purposes, both by night and day, whilst a small enrichment cylinder might be attached to the gas outlet pipes from the consumer's meter, and this would be made to automatically enrich the gas supplied to his house, so that by setting a valve he could have any quality he might desire.

Comparison by illuminating power.

The economic value of an illuminant such as acetylene becomes apparent when we compare the cost of the gas for equal illumination with the light obtained from other illuminants. The London gas has an illuminating power of 16 candles, whilst the acetylene has an illuminating value of 240 candles, and this at 6s. 4½d. per 1,000 would in light-giving value be equivalent to London coal-gas at less than 6d. per 1,000.

In order to obtain a given illumination, moreover, the volume of gas to be consumed is excessively small, as compared with any other illuminating gas, and the products of combustion are reduced to an excessively low limit. One hundred cubic feet of London coal-gas will yield 50 cubic feet of carbon dioxide and 140 cubic feet of water vapor as the products of its complete combustion, whilst 100 cubic feet of acetylene would yield 200 feet of carbon dioxide and 100 feet of water vapor. The acetylene however in its combustion gives a light of 240 candles, as against 16 yielded by the coal-gas; and for equal illumination therefore the amount of carbon dioxide and water vapor produced is enormously smaller.

The following table contrasts the products of combustion evolved from London coal-gas, when consumed in various forms of burners and giving an illumination of 48 candles, which may be presumed to be the amount of light required in a fair-sized London dining-room, and contrasted with this is the amount of the products of combustion which acetylene would evolve in giving the same amount of light; whilst to make the meaning clearer, I have added the number of adults who would exhale the same amount of carbon dioxide in the same time.

Burner.	Gas consumed.	Carbon dioxide produced.	Adults.
Flat flame, No. 6	19.2	10.1	16.8
Flat flame, No. 5	22.9	12.1	20.1
Flat flame, No. 4	25.3	13.4	22.3
London Argand	15.0	7.9	13.1
Acetylene	1.0	2.0	3.6

If we obtained the same amount of light from paraffin lamps, the carbon dioxide evolved would be equivalent to 22.5 adults; whilst as far as carbon dioxide goes you might as well invite 32.7 guests to dinner as use 48 sperm candles to supply the needed illumination.

Temperature of the acetylene flame.

The flame of acetylene in spite of its high illuminating value is a distinctly cool flame, and in experiments which I have made by means of the Le Chatelier thermo-couple, the highest temperature in any part of the flame is a trace under 1,000°C., whilst with coal-gas burning in the same way in a flat-flame burner the temperature rises as high as 1,360°C. If the heating effect of the flames be contrasted for equal illumination, it will be seen that the acetylene flame has so small a heating effect, considering its area, that it would not be much greater than the ordinary electric incandescent lamp

The intensity of the light will make small acetylene lamps of enormous value for lantern projection, for railway signals, and, coming down to smaller

things, bicycle lamps, whilst I should imagine the ease of production specially adapts it for such purposes as lighthouse illumination.

The scope and possibilities of such a disoovery as that which I have brought before you this evening cannot be realized until many factors at present unknown are thoroughly worked out, and you must remember also that the time at my disposal has only enabled me to bring before you to-night some facts connected with the light-giving value of this hydrocarbon, and that as a stepping-stone to the synthesis of other bodies its value will be incalculable. One cannot help feeling that as science grows, and as our grasp and comprehension of the marvellous processes by which nature builds up her matter become more and more extended, synthesis may have even greater conquests to make than the mere building up on a commercial scale of an illuminating hydrocarbon.

Outlook of the discovery along other lines.

We are beginning to realize more and more fully the marvellous way in which nature keeps matter in circulation, the way in which animal and vegetable structures are built up from the simplest and most plentiful substances, and the way in which, when the structure is done with, those processes of slow combustion which we call decay again convert the waste bodies into carbon dioxide and water vapor, from which once more nature reconstructs the vegetable and animal kingdom ; and it may be that as our perception of the methods of that marvellous natural architecture gets clearer and keener, we may discover how, by simple synthetic processes, the carbon dioxide and water vapor which form nature's building material may be synthetically utilized by us in building up, not the perfected form of man, or animal, or plant, but the building on a commercial scale of the food which is required by nature for carrying on the functions necessary for life. [5]

[5] The London Journal of Gas Lighting made the following comments on Prof. Lewes' paper and the experiments with which it was illustrated :

"The time was Wednesday, January 16th ; the place the well known lecture theatre of the Society of Arts, London ; the man, Professor Vivian B. Lewes, and the matter Commercial Acetylene. From this combination resulted, then and there, a sensation which, unless appearances are utterly illusory, will echo and re-echo through the industrial world for a very long time to come. When the announcement was made that Professor Lewes would read a paper on 'The Commercial Synthesis of Illuminating Hydrocarbons,' no indication was given of the particular turn which the communication would take, but that a high degree of interest and importance would be found to attach to Professor Lewes' matter was foreshadowed by the steps taken with the co-operation of Sir H. Trueman Wood, the Secretary of the Society, to secure a fit audience for the occasion. In consequence of this effort, a goodly contingent of gas engineers and others interested in the gas industry put in an appearance at the Society's house last Wednesday evening ; but it is not to be supposed that a single individual among this critical portion of the audience had the faintest expectation of what was coming, or entertained the slightest idea that he was about to assist at what will in all probability come to be regarded throughout the gas and the allied interests as an epoch-making demonstration. Professor Lewes' and the Society's secret was perfectly kept, and its disclosure at the proper time was therefore all the more astounding. For his design was no other than the first exhibition to the world of one of the most striking of the fruits of modern scientific discovery in the new territory of physico-chemistry, the product of that remarkable research of Mr. T. L. Willson—carbide of calcium—the nature and properties of which were by a pure coincidence described in our last week's Technical Record. The absorbing interest of this programme, and the brilliant manner in which it was carried out, are not likely to fade from the minds of those who had the good fortune to attend on this historic occasion.

"What Professor Lewes said will be found reported in full in another column. Our present purpose is to draw attention to the text of the paper and to supplement it with independent testimony as to the demonstrations by which the lecturer proved his statements. He commenced by laying out the ground for the structure he was about to raise, inviting the attention of his audience to the twin methods of chemical research, analysis and synthesis, to make it quite plain that he was not going to ask them to take from him anything arrived at by occult means or needing to be hedged about by the devices of charlatanry. Only too often in the history of so-called new discoveries in chemical industry, there is something

THE CARBIDES AND ACETYLENE COMMERCIALLY CONSIDERED.[6]

By T. L. Willson and J. Suckert, Ph.D.

Methods of formation, and chemical and physical properties of the compounds.

Before entering upon the subject matter of this paper, namely, the commercial consideration of the carbides and acetylene, we believe that a brief history of these compounds, their methods of formation and their chemical and physical properties, will be of interest to you. That carbon will combine directly with various metals under the influence of heat has long been known to chemists, but these compounds, generally known as 'carbides,' have been but imperfectly studied, and, with the exception perhaps of the carbides of iron, are hardly known.

Carbides of the alkali and alkaline earth metals,

The only group of carbides which interests us this evening is that of the carbides of the alkali and alkaline earth metals, such as the potassium, sodium, barium, strontium and calcium carbides ; for the reason that these are the only carbides which when brought into contact with water will decompose it, forming generally the hydrated oxide of the metal and acetylene gas. Of these latter carbides, the combination of calcium with carbon has the greatest commercial possibilities on account of the low first cost of the raw materials which enter into this combination, namely, lime and coal, the abundant

kept back. The result, whatever it is, is stated to be attained by the employment of some 'chemical,' the nature of which is not disclosed. Of course a man of reputation in science does not mix himself up in such schemes ; but things of this kind occur often enough to point the observation we now offer regarding the transparency of Professor Lewes' exposition. And when the lecturer had by easily followed steps arrived at the top of the first stage of his structure—the announcement that it was the synthesis of acetylene in bulk which it was his purpose to deal with—he was careful to show that there is nothing absolutely new about carbide of calcium or the phenomenon of its giving off acetylene when wetted with water. He carefully told the story of the early experiments with this compound ; and only 'let himself go' in the capacity of the exhibitor of a new thing when he came to deal with the production and uses of it on a commercial scale by the method of Mr. Willson.

"And a very startling exhibition it was—as utterly fresh and convincing as good matter in the hands of a master in the art of science exposition could make it. Carbide of calcium as known to science, was a chemical curiosity until Mr. Willson happened upon a way of preparing it in bulk in the course of his experiments upon the manufacture of calcium alloys by the agency of his electrical furnace. But this discovery put a new face upon the compound. When an article that has only existed in grains comes to be turned out by the ton, it is to all intents and purposes a new article. In this sense carbide of calcium is very new indeed ; and its industrial possibilities are newer still, inasmuch as only the most direct and obvious of these developments have as yet been so much as hinted at.

"Take it that the material can be produced by the ton, and it is impossible to surmise what chemical industry will be able in the fulness of time to make of it. The product of fusing together in an electrical furnace such common materials as lime and carbon in any suitable form was exhibited by Professor Lewes as a greenish-gray stone-like substance greatly resembling the commonest description of serpentine rock. When kept in the air a light coating of lime soon forms on its surface. Upon handling it a faint, unpleasant odor, suggestive of garlic, and also not altogether unlike the familiar reek that emanates from the ironwork of an old gas-purifier, manifests itself. To all appearance it is a dull, inert stone, devoid of any other properties than those of common road metal, and not much likely to be credited by the casual observer with gas yielding capabilities. Upon a piece of this material Professor Lewes sprinkled a few drops of water from a wash bottle, and put a lighted taper to it. The nascent gas—acetylene—immediately ignited with more than the brilliancy of the pitchy flame of highly bituminous coal in an open fire, and continued to burn fitfully over the wetted surface until all the water was gone. Then came the display of the same gas evolved in a jar (standing upon the lecture table), which contained pieces of the carbide in water and stored in make-shift glass holders. It was a dramatic denouement of Professor Lewes' little plot when he applied a light first to a single open flat-flame burner, and then to a group of five similar burners, and people saw for the first time in a public place the intensely brilliant white and solid looking flame of burning pure acetylene.

"It is indeed a flame to wonder at. Nothing like it ever before came within the ken of a gas manager or dazzled the vision of a photometrist. There is something startling in the suggestion that gas of 240 candle power—calculated in accordance with photometrical practice, upon the basis of a consumption of 5 cubic feet per hour—can be burnt by means

[6] A paper read at the Franklin Institute, Philadelphia, March 20th, 1895.

deposits of same in all quarters of the globe, and the commercial value represented by the by-product, hydrate of lime, which is obtained in large quantities by the decomposition of the calcium carbide with water.

The history of the discovery and methods of production of this group of carbides may briefly be stated as follows: and their history.

The first authentic reference to this subject was the discovery by Sir Humphrey Davy that carbon and potassium, when heated to a temperature sufficiently high to vaporize the potassium, formed a compound which after cooling would effervesce with water.

Berzelius in 1836 determined that the black substance formed in small quantities as a by-product in producing potassium from potassic carbonate and carbon was carbide of potassium.

Woehler in 1862 prepared calcium carbide by fusing an alloy of zinc and calcium with carbon, and ascertained that it decomposed by contact with water, forming calcic hydrate and acetylene.

Berthelot in 1866 described sodium carbide or acetylene sodium. He produced it by the following method: Metallic sodium, when slightly heated in acetylene gas, puffs up and absorbs acetylene with the formation of the compound C_2HNa. At a dull red heat sodium destroys acetylene, forming a black carbonaceous mass, C_2Na_2. The reaction is expressed by the following

of an open flat-flame burner. When the carbide of calcium first came into Professor Lewes' possession this had not in fact been done, and in order to get a flame of acetylene at all the American handlers of the gas had fallen back upon the brutal device of diluting it with a certain proportion of air. This was to repeat the crude American way of rendering naphtha gas usable. But the dilution of acetylene with air is even more objectionable than is the same treatment in regard to naphtha gas, inasmuch as it is more easily converted into a violent explosive mixture. Professor Lewes, in succeeding in burning acetylene in the pure state in which it comes from the mixture of calcium carbide and water, has saved its prospects as an illuminant. He showed on Wednesday those wonderful acetylene gas flames already mentioned, each produced by burning the gas as made in the simple way described, without any adventitious mechanical or chemical aid, after the rate of half a cubic foot per hour, and stated to yield a measured illuminating power of 25 candles. This could easily be credited. But what it is more difficult to convey in mere words is the impression of steadfastness, whiteness and, so to speak, solidity which the flames in question made on the observer. At a little distance no non luminous zone could be perceived, but on a close inspection a tiny speck of blue over the top of the burner was visible. No smoke or smell escaped from these flames, which, although exhibiting in their color the evidence of intensely active combustion, were found to be much cooler than oil-gas or albo-carbon gas flames of the same size. This is a most striking feature of free burning acetylene. The incandescent electric lamps of normal brilliancy by which the lecture theatre was lit were made to look as dull as 'red-hot hair-pins' by the aggressive acetylene, which itself by virtue of the irradiation produced by its dazzling white flame appeared to form balls of almost blinding light when viewed directly in face or sideways of the flame. The mantle of the incandescent light is no whiter than, if it is so white as, the naked acetylene flame, which does not flicker or change color; but in the absence of means of making a direct comparison between the two lights it is rash to say which would bear the palm for purity of tint.

"It is not for us to say what may be done with this new servant of a community that ever clamours for more light, and gets it more easily and cheaply every day. Considerations of the cost at which the carbide of calcium will be producible, and of the prospects of its utilization as a means of generating portable gaslight or as an enricher of common coal gas, suggest themselves to every one who sees or hears of the substance and its qualities. But it is premature to discuss such questions at present; all that need be said upon these points for the time being was said on Wednesday by Professor Lewes, and by those who took part in the extremely cogent little discussion that followed his brilliant discourse. When the time is ripe for more it will doubtless be forthcoming. Meanwhile it is only doing justice to all the parties concerned in last Wednesday's memorable proceedings in the Adelphi to acknowledge the high interest of the whole subject, and the adequate manner in which it was presented to the general and technical public. The discoverer of the system is to be congratulated upon the promise of the new industrial development; Professor Lewes may be complimented upon the deft and convincing way in which he performed the part of introducer of the novelty; and—if last not least—the Society of Arts deserves to be credited with having proved once more the practical value of the agency wielded by the council and secretary of this useful institution for giving publicity readily and promptly to warrantable novelties in science and the industrial arts."

formula: ($C_2H_2 + Na_2 = C_2Na_2 + H_2$). This compound, C_2Na_2, in contact with water, regenerates acetylene.

A stage of non-progress.

From 1866 until 1888, a period of twenty-two years, nothing further has been recorded of scientific work done in this direction; as a matter of fact, the compounds so produced were not only very impure, but their cost of production also was so great as to render their commercial use prohibitory; they were considered as curiosities, and looked upon by scientists as such.

Willson's experiments with the aid of an electric furnace,

In 1888 Mr. T. L. Willson began a series of experiments relating especially to the reduction of refractory metallic oxides by carbon in an electrical furnace. By this method the reductions were to be accomplished by the heat effect of the current alone, and not by electrolytic action.

and the various results obtained.

The results of these experiments, which were numerous, and which extended over a period of years, developed some very interesting data as to the action of intense heat on refractory bodies generally, and especially as to the formation of carbides in large quantities. Mr. Willson found that lime, baryta, strontia and even alumina, when subjected to the intense heat of his electric furnace, were liquefied and formed a molten mass, which could be brought to ebullition. An addition of carbon thereto caused a decomposition of the oxide, carbon monoxide being formed, while the fused metal united instantly with the excess of carbon previously introduced to form a carbide. Further experiments developed the fact that when a mixture of powdered lime and coke dust was introduced into the furnace the mixture would melt down to a thick syrupy mass of practically pure carbide of calcium, and that this when removed from the furnace and brought in contact with water evolved acetylene gas in large quantities. The carbides of barium, strontium and aluminium also were prepared in the same manner, and the specimens now before you are the results of these earlier experiments.

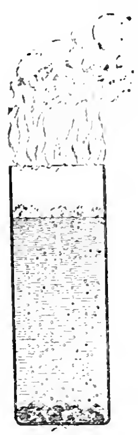

Fig. 1.

We will now introduce a small quantity of each of these carbides into different vessels containing water at ordinary temperature. The carbides of barium, strontium and calcium decompose water readily, forming the respective hydrates of their metallic oxides and acetylene gas, which we now ignite as it is being evolved in each vessel; the resulting gas, as you observe, burns with a luminous sooty flame (see Fig. 1). As the carbide of aluminium does not react with water at ordinary temperatures, no gas is evolved from the fourth vessel.

This substantially completes the history of the alkali and alkaline-earth metal carbides up to the date of Mr. Willson's discovery.

Carbide of Calcium and Acetylene.

Properties of pure calcium carbide.

The physical and chemical properties of pure calcium carbide, as first prepared in the Willson furnace, and which we now hand you for inspection, are those of a dark brown, dense substance, having a crystalline metallic fracture of blue or brown appearance, and a specific gravity of 2.262; it evolves a peculiar

odor when exposed to the atmosphere, due to the action of atmospheric moisture. In a dry atmosphere it is odorless. When exposed to the air in lumps it becomes coated with a layer of hydrate of lime, which to a great extent protects the rest of the substance from further deterioration by atmospheric moisture. It is not inflammable, and can be exposed to the temperature of the ordinary blast furnace without melting. When exposed to the flame of a Bunsen blast lamp it can be heated to a white heat, the exterior only being converted into lime. When brought into contact with water or its vapors at ordinary temperatures, it is rapidly decomposed, one pound generating when pure 5.892 cubic feet of acetylene gas at a temperature of 64° F. It also decomposes with snow at a temperature of — 24° F. It is not acted upon by the vapor of water at high temperatures. It abstracts moisture readily from alcohol, also from liquefied ammonia gas, rendering the latter anhydrous. If small pieces are treated with common sulphuric acid, a violent reaction ensues. Acetylene is generated with considerable increase in temperature. If however large pieces are plunged into common sulphuric acid, the reaction is feeble.

An exhaustive series of experiments made by Dr. H. Schweitzer of New York have shown that when treated at a red heat with dry muriatic acid gas, the carbide is decomposed with the formation of free carbon and small quantities of a yellow substance easily soluble in ether. When treated with steam at different temperatures, (up to 428° F.), and different pressures (up to 35 atm.), the material was decomposed with the formation of but small quantities of the same yellow substance, and not in sufficient quantity for further examination.

Benzol, nitro-benzol, phenol, aniline, toluidine and other organic compounds gave no reaction when treated with carbide of calcium alone, and in the presence of water, at varying pressures and temperatures. It would appear from the foregoing to be a very inert body in its action on other compounds, and in view of this fact the ease with which it decomposes water at ordinary temperatures is remarkable.

When treated with water in a closed vessel properly cooled, acetylene gas continues to be evolved from the material at pressures exceeding 75 atm. Calcium carbide has the chemical formula CaC_2, and contains in 100 parts 62.5 parts of calcium and 37.5 parts of carbon. **Acetylene gas,**

The gaseous product of the decomposition of the alkali and alkaline earth metal carbides with water, namely, acetylene, is an unsaturated hydrocarbon of the series C_nH_{2n-2}, having the chemical formula C_2H_2, and containing therefore in 100 parts 92.3 parts of carbon and 7.7 parts of hydrogen. **its composition**

It was first recognized and its chemical constitution determined by Berthelot in 1849. It has heretofore been formed in small quantities by passing ethylene, or the vapors of alcohol, wood alcohol, ether and other organic compounds through a red-hot tube. It is present in coal gas to the extent of 0.06 per cent., and water gas contains almost 1.0 per cent. It has also been formed by passing hydrogen gas between carbon points brought to incandescence by the electric current, which is the first recorded synthesis of an organic compound directly from its elements. It can also be produced by the **and history.**

incomplete combustion of the vapors of ether, amylene, etc.; or of illuminating gas, in the interior of a Bunsen burner; by passing the vapor of chloroform over red-hot copper; or from chloroform and potassium amalgam; or from chloroform and sodium; or by the electrolysis of fumaric and malic acids; by passing the vapor of ethylene chloride over red-hot soda lime, and finally, by allowing ethylene bromide to drop in a boiling concentrated solution of alcoholic potash, passing the impure acetylene into an ammoniacal cuprous chloride solution, washing the red precipitate with water, and whilst still moist boiling it with concentrated hydrochloric acid.

Properties of the gas.

Acetylene is a colorless gas, having a penetrating pungent odor somewhat resembling garlic, which is of great importance in its application to household illumination, as it renders the slightest escape of gas in a room easily detectable. It has a specific gravity of 0.91, and burns with a luminous sooty flame. It is soluble in water in about the same proportions as carbon dioxide, that is, at 64° F. water will absorb its own volume of the gas. Absolute alcohol and glacial acetic acid dissolve about six times their volume. It is practically insoluble in saturated brine, 100 volumes absorbing but five volumes of the gas, whereas paraffin will absorb two and one-half times its volume. By heating acetylene to the softening point of glass, benzol (C_6H_6), styrolene (C_8H_8), naphthalene ($C_{10}H_8$), anthracene ($C_{14}H_{10}$), and reten ($C_{18}H_{18}$), are formed.

With an alkaline solution of permanganate of potash acetylene is oxidized to oxalic acid, and with a dilute solution of chromic acid to acetic acid. By treating acetylene copper with zinc and ammonia ethylene is formed, and a mixture of acetylene and hydrogen brought in contact with platinum black forms ethane. By the electric spark acetylene is resolved into carbon and hydrogen, at the same time a fluid and a solid poly-acetylene are formed; the latter resembles horn, and is insoluble in the ordinary solvents A mixture of nitrogen and acetylene is converted by the induction spark into hydrocyanic acid.

It may be heated to a temperature of 370° F., and under a pressure of 43 atmospheres, without decomposition.

May be condensed into a liquid.

The gas can readily be condensed to a liquid, as is evidenced by the following table, the pressures being considerably less than those required for carbon dioxide:

Acetylene.		Carbon dioxide.	
Fahr.	Atmospheres.	Fahr.	Atmospheres.
— 116.°	1.0	— 112.°	1.0
— 28.6	9.0	— 23.2	12.7
— 9.4	11.01	— 4.	19.93
+ 14.	17.06	+ 14.	26.76
32.	21.53	32.	35.40
41.45	25.48	41.	40.47
56.3	32.77	59.	52.17
67.27	39.76	68.	58.84

Pressures and specific gravities.

The critical point of the gas has been placed by Ansdell at 98.69° F. He also determined the specific gravity of the liquefied gas at various temperatures, placing the density at about one-half that of carbon dioxide; but his results do not agree with those obtained by us in the production and storage of large quantities of the liquefied gas. For instance, the small tank to which

this connecting pipe and burner are attached (Fig. 2) should contain according to Ansdell, when filled at 69.08° F., about 2.15 pounds of liquefied acetylene; as a matter of fact however we can fill into this tank somewhat more than two and three-quarter pounds of the liquefied gas. We are now engaged in preparing a new table of pressures and specific gravities of the liquefied gas, and will be pleased to communicate the results to you at a later date.

One pound of the liquid when evaporated at 64° F. will produce fourteen and one-half cubic feet of gas at atmospheric pressure; or a volume 400 times larger than that of the liquid.

Fig. 2.

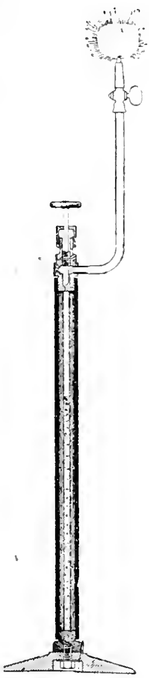

Fig. 3.

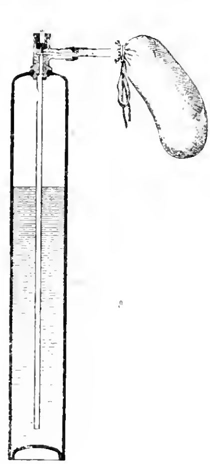

Fig. 4.

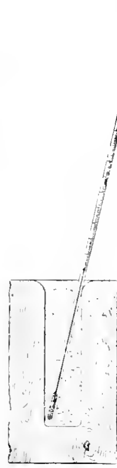

Fig. 5.

Liquefied gas.

The odor of the gas has already been made apparent to you whilst the experiment showing the decomposition of the various carbides with water was being carried on. We will now show you the liquefied gas contained in this glass tube surrounded by a metal casing (Fig. 3). As you will observe, the liquefied gas forms a colorless, mobile, highly refractive liquid, which when the pressure is slightly relieved commences to boil and evolves a gas which, ignited as it issues from this gas tip burns with an intensely white flame. If the liquefied gas be suddenly relieved of its pressure, or allowed to escape in its liquefied state to the atmosphere, a portion evaporates rapidly, thereby abstracting from the remaining portion sufficient heat to solidify it. This tank, which is now shown you (Fig. 4), contains liquefied acetylene, which has been cooled to a temperature of —28° F. in order to prevent the escape of too large a volume of gas during the process of its solidification. Attached to this valve, inside of the tank, is a tube which reaches within half an inch of the tank bottom, and is open at its lower end. We now attach to the valve a flannel bag to receive the solidified gas. Upon opening the valve the liquefied gas escapes, the solidified portion remaining in the bag, while the

gas formed escapes through the pores of the bag. This bag will hold about three-quarters of a pound of the solidified gas, and this is about the quantity which is now being emptied on the plate. A portion of this solidified gas will now be passed to you for inspection ; another portion is packed into this wooden tube, a thermometer is inserted (Fig. 5), and, as you will observe, the temperature falls to — 118° F. Another portion is placed on one pound of mercury contained in this saucer (Fig. 6) ; the intense cold of the solidified gas almost immediately solidifies the liquid metal. A portion of the solidified gas or "acetylene snow" is now dropped into this vessel (Fig. 7), containing water. Being lighter than water it floats upon its surface, and when touched with a light the gas surrounding each particle of the solidified gas burns with a sooty flame, and continues to burn until all the solidified gas has disappeared.

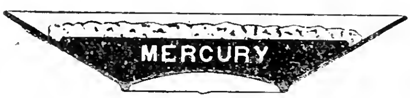

Fig. 6. Solidified gas.

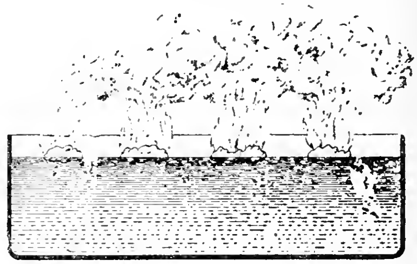

Fig. 7. Flame of solidified gas.

Acetylene snow, or solid gas.

I will now ignite the gas evolving from the acetylene snow contained in this dish, and you have the interesting exhibit of a solidified gas at — 118° F. giving off gas which can be ignited, and which, although evolved at this low temperature, possesses the same illuminating power as at higher temperatures.

You have now seen acetylene in its three physical conditions, namely, as a gas, a liquid and a solid; and the mere fact that it readily assumes the gaseous and liquid condition is of vital importance to its commercial application.

Commercial Application of the Compounds.

Experiments to determine commercial value in other directions.

Having described the physical and chemical properties of calcium carbide and the product of its decomposition with water—acetylene—we will now consider the commercial possibilities of these compounds.

Carbide of calcium, as we have already shown, is a rich source of acetylene, but beyond this we cannot at present definitely designate additional commercial applications of this material.

Extended experiments are now being conducted to determine its commercial value in the production of cyanides and various nitrogenous compounds, in the manufacture of iron, steel and other metals, and their alloys, and in its application to the synthetical formation of various organic compounds.

The results thus far obtained however, although encouraging, do not as yet justify us in accepting them as commercially applicable.

Method and cost of production.

As the commercial value of any material largely depends upon its cost of production, its purity and the value of the products and by-products obtained

therefrom, our first consideration will be the method of manufacturing the carbide of calcium and the cost of the finished product.

The carbide of calcium originally prepared by Mr. Willson during his first experiments was produced at a cost largely in excess of that for which it can be manufactured to-day, but a description of these original experiments will without doubt be of interest to you.

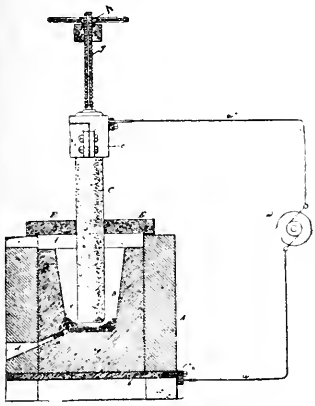

Fig. 8. Furnace for producing calcium carbide.

The first experiments were made with a dynamo generating a current of 150 ampères at from 60 to 70 volts. The furnace consisted of a plate of carbon 12 inches square and one inch in thickness, along one edge of which an iron rod was bolted and projected beyond the mason work, and to which one terminal from the dynamo was connected. This carbon plate was embedded in brickwork, having only a small central portion exposed, upon which the graphite crucible rested. From one terminal of the dynamo the current was conducted through the iron rod, carbon plate, graphite crucible, the material to be acted upon, and the carbon pencil, to the other terminal. To start the furnace, the pencil was placed in contact with the bottom of the crucible and the dynamo was started up slowly. As the electromotive force increased the pencil was withdrawn from the bottom of the crucible and the 'arc' established.

Description of the first electric furnace used,

The material to be acted upon was then introduced through an opening in the cover of the crucible, the cover being either of non-conducting material, or, if of graphite, insulated from the crucible by a non-conducting luting. One of the pencils from the original lot used in these earlier experiments is now before you. This carbon pencil is 12 inches long, $1\frac{1}{4}$ inches in diameter, copper-plated and has a hole bored through its entire length, the tube so formed being used for the introduction of gaseous agents. With this furnace various metallic compounds, intermingled with pulverized carbon and also surrounded by gaseous reducing agents, were subjected to the intense heat developed by the electric arc.

The success attending the operation of this first furnace, in the reduction of refractory metallic oxides, justified the continuation of the experiments upon a larger scale, and to this end the Willson Aluminum Company was organized and a plant erected at Spray, North Carolina. This plant was supplied with a dynamo, operated by water power, and generating a current of 2,000 ampères at 35 volts. The furnace was constructed as here shown (Fig. 8), namely:

and of the second furnace.

A designates the outer masonry shed or bench of the furnace; *B* the carbon or graphite crucible or hearth; *C* the carbon bar or pencil constituting the moveable electrode, and *D* the dynamo for generating the current. From the terminal brushes of this dynamo one wire, *w*, leads to and communicates with the crucible *B*, while the other wire, *w'*, leads to and communicates with the carbon pencil *C*. The connections are usually made in the manner shown, the

wire w being connected through a fastening-bar a to an iron plate b, underlying the crucible B, and the wire w' being connected to a metal socket c, embracing the upper end of the carbon pencil C. The bench A is generally made of firebrick, which is a non-conductor of electricity, and the furnace is covered with a plate or, preferably, two plates, EE, of carbon, having a central hole through which the carbon pencil C projects down into the crucible.

For tapping out the resulting product a tap-hole d is formed, which in operation is closed by a plug e, of clay or other suitable refractory material. The carbon plates EE rest on the top of the firebrick walls A, which project above the top of the crucible, forming an intervening space f for the furnace, between B and E. For the vertical adjustment of the carbon pencil a screw-threaded shaft g is provided, which may be moved up and down by the engagement therewith of a suitably mounted rotative nut h.

First run of the furnace.

The first carbide of calcium produced in this furnace, in accordance with memoranda taken at the time by Mr. Willson, was manufactured as follows: A mixture of lime and tar was boiled in a caldron, in the proportion of 60 pounds of lime to 11 gallons of coal-tar, and the heating was continued until the mixture was perfectly dry. It was then introduced into the furnace and subjected to the heat of the electric arc for a period of two hours, gradually feeding the mixture of lime and tar to the furnace as fusion took place. The product obtained consisted of a purplish-yellow mass, which in contact with water evolved acetylene gas. A sample of the calcium carbide produced upon this occasion is now before you, and represents the first calcium carbide produced in an electrical furnace.

The experiment was repeated with a mixture of 15 pounds of tar in fused lime and alumina, the time required for the operation being one and one-half hours.

The product obtained was a black, crystalline mass, consisting of a double carbide of calcium and aluminium. A sample of this double carbide is also submitted for your inspection.

Another run, made with a mixture of 10 pounds of lime and 10 pounds of finely divided carbon, operating one hour, resulted in the production of a dark crystalline mass, showing at its fracture black and blue crystals. A small metallic ingot was found in this mass, and a similar ingot of this white metal is now before you.

A fourth test, made with $17\frac{1}{2}$ pounds of lime and $17\frac{1}{2}$ pounds of carbon, resulted in obtaining 11 pounds of almost pure calcium carbide.[7]

Successful results obtained.

The tests described represent but a few of the numerous experiments conducted by Mr. Willson in his efforts to successfully and economically produce calcium carbide on a large scale. Recent results in the application of the alternating current to its manufacture prove conclusively that calcium

[7] A sample of the carbide obtained during the last test was sent by Mr. Willson to Lord Kelvin of Glasgow University, and in return the following reply was received:

The University, Glasgow, October 3, 1892.

Dear Sir :—I have seen and tried the calcium carbide, only however so far as throwing it into water and setting fire to the gas which comes off. It seems to me a most interesting substance and I thank you very much for sending it to me. Yours very truly,

Thomas L. Willson, Esq. KELVIN.

carbide of a remarkable purity can be commercially produced. The product now being manufactured, in quantities exceeding one ton per diem, will readily evolve in contact with water $5\frac{3}{4}$ cubic feet of acetylene gas per pound of the carbide used, a result closely approaching to that which is theoretically possible, namely, $5\frac{89}{100}$ cubic feet per pound of carbide.

Theoretical proportions.

The theoretical proportions of lime and carbon required for the production of 100 pounds of calcium carbide are, $87\frac{1}{2}$ pounds of lime and $56\frac{1}{4}$ pounds of carbon. Of the latter $37\frac{1}{2}$ pounds combine directly with the metal calcium; and $18\frac{3}{4}$ pounds combine with the oxygen of the lime, and escape from the furnace as carbon monoxide, in accordance with the following formulæ :

$$
\begin{aligned}
CaO + C_3 &= CaC_2 + CO \\
87\tfrac{1}{2} + 56\tfrac{1}{4} &= 100 \quad + 43\tfrac{3}{4}\ \text{(lb.)} \\
CaC_2 &= \ Ca \quad + C \\
100 &= 62\tfrac{1}{2} \quad + 37\tfrac{1}{2}\ \text{(lb)} \\
CO &= \ C \quad + O \\
43\tfrac{3}{4} &= 18\tfrac{3}{4} \quad + 25\ \text{(lb.)}
\end{aligned}
$$

Data for estimating quantity and cost of production.

A further element of cost in its manufacture is the production of heat in the furnace by means of the electric arc. Extended experiments in this direction have shown that one electrical horsepower will readily produce twenty pounds of calcium carbide each twenty-four hours, and the present indications justify the assumption that with automatically-fed furnaces, properly insulated to retain the heat, and by utilizing the waste heat to increase the temperature of the material acted upon, the production of calcium carbide can be increased on a large scale to thirty pounds per electrical horsepower each twenty-four hours.

By using limestone and coal dust, the latter being practically a waste product (not at present utilized), it is believed that calcium carbide can eventually be produced at a cost of less than $5 per ton. Where bituminous coal is employed, the value of the by-products obtained by its conversion into coke will largely reduce the cost of manufacture.

The hydrate of lime obtained from the decomposition of the carbide with water can be used again in the manufacture of the carbide, or it can be employed in the manufacture of ready-mixed mortar, which is already quite an industry in this city.

Arrangements to utilize electric power at Niagara Falls to manufacture calcium carbide.

Arrangements are now being made by the Electro-Gas Company of New York city with the Niagara Falls Power Company to apply 1,000 electrical horse-power to the manufacture of calcium carbide, which is shortly to be increased to 5,000 horse-power, and eventually we will without a doubt see the entire available power the company now possesses converted into electrical energy for the manufacture of this product. The effect of such a production would be far-reaching, and the economies resulting therefrom, if stated to-night, appear exaggerated and visionary. Assuming that but 20 pounds of the carbide are produced per indicated horsepower each 24 hours, then the amount manufactured during 300 working days would be 3 tons per horsepower per year; and, applying 100,000 horsepower to its production, the annual output of such an establishment would be 300,000 tons. From this amount of material 3,300,000,000 cubic feet of acetylene gas should be produced, and as its illuminating power compared with ordinary illuminat-

ing gas of 25 candle-power is as ten to one, it would represent fully 33,000,000,000 cubic feet of this gas—an amount which would probably equal the annual output of the entire gas industry of the United States.

As this is but one of the many applications of the product obtained by the decomposition of the carbide with water, the manufacture of the carbide itself must of necessity become a large industry.

Contents of the calcium carbide.

As we have previously informed you, pure calcium carbide contains in 100 parts 37.5 parts of carbon and 62.5 parts of calcium, and when brought in contact with water acetylene is generated to the extent of 5.89 cubic feet of the gas to each pound of carbide used; or if compared by weight, 100 pounds of calcium carbide and 56.25 pounds of water evolve 40.63 pounds of acetylene gas, and form 115.62 pounds of calcic hydrate, in accordance with the following formula:

$$\begin{array}{ccccc} CaC_2 + 2H_2O & = & CaOH_2O & + & C_2H_2 \\ 100 + 56.25 & = & 115.62 & + & 40.625 \text{ (pounds.)} \end{array}$$

The acetylene gas so generated contains in 100 parts 92.3 parts of carbon and 7.7 parts of hydrogen, or in the 40.625 pounds generated from 100 pounds of carbide, we have $37\frac{1}{2}$ pounds of carbon and $3\frac{1}{8}$ pounds of hydrogen. The entire carbon contained in the calcium carbide has therefore combined with the hydrogen of the decomposed water to form a new compound of a gaseous nature and extremely rich in carbon.

In its commercial application acetylene can be produced either directly from the calcium carbide by decomposition with water, or it may be evolved from the liquefied gas contained in suitable receivers.

Methods employed in producing the gas.

When manufactured directly from the carbide, two methods can be employed; in one, small quantities of water are allowed to flow upon the carbide and the resulting gas is conducted to an ordinary gasometer, from which it can be drawn for use; this method is more or less intermittent. The other method dispenses with a gasometer and permits the continuous generation of either large or small quantities of the gas, and this is accomplished by partially submerging in water a vessel, open at the bottom and containing carbide suspended on a screen in the upper part of the vessel, the generated gas being withdrawn from above the carbide. As long as gas is being used the water remains more or less in contact with the carbide; as soon however as the withdrawal of gas diminishes or entirely ceases, the pressure of the generated gas forces the water from the carbide into the lower chamber of the vessel, thereby preventing a further generation of the gas. The apparatus is automatic and extremely regular in its operation.

In the employment of either of the above methods the only by-product obtained is slaked lime, the amount of gas produced being the same, namely, $5\frac{1}{2}$ cubic feet for each pound of calcium carbide used.

The liquefied gas is manufactured commercially by decomposing the carbide of calcium with water in a closed vessel and conducting the gas generated under pressure to a condenser, where it liquefies and is then drawn off in tanks ready for distribution.[8] The liquefied gas exhibited this evening has been produced in this manner.

8 A full description of this process and of the apparatus required therefore is contained in U. S. Patent No. 535,944, March 19, 1895.

Before entering upon the use of acetylene as an illuminant, we desire to call your attention to the fact that its rapid and extraordinary development in this direction is largely due to the individual efforts of Mr. E. N. Dickerson of New York city, who, endowed with a special knowledge of the subject, has labored unceasingly to bring about the successful result which you will see this evening.

COMPARATIVE VALUE OF ACETYLENE.

Acetylene as an illuminant compared with coal or water gas.

As an illuminant, acetylene surpasses in lighting power and economy all other illuminants known; when burned at the rate of five cubic feet per hour it produces a light equal to 250 candles, whereas the best illuminating gas made from coal, or water gas, rarely exceeds twenty-two candles for each five cubic feet burned per hour. Your Philadelphia city gas is rated at from nineteen to twenty candles. Acetylene gas will therefore produce twelve and one-half times more light if the same quantity be consumed, or 1,000 cubic feet of acetylene gas will give you the equivalent in lighting power of 12,500 cubic feet of your city gas; it has therefore twelve and one-half times the value. To illustrate more fully the difference, we will first pass your city gas to the tube attached to this stand, and ignite the gas as it issues from the burners; we then conduct acetylene gas to a similar row of burners, and light these; the contrast, as you will perceive, is almost marvellous.

Testing the gaseous and liquefied forms of acetylene.

The acetylene consumed in these burners has been generated in the apparatus before you in the following manner: Upon the carbide contained in this closed jar (Fig. 9) water is poured in small quantities through the glass funnel communicating with the interior of the jar. The acetylene gas generated passes through this tube to the inside of the gasometer, thereby lifting the holder to the position which it now occupies, and the gas can then be conducted from the holder to the burners by means of this rubber tube. As the gas is being consumed and the holder lowers, the supply is rapidly renewed by pouring an additional amount of water through the funnel upon the carbide contained in the closed jar. We will also light the gas produced from liquefied acetylene contained in this small tank (Fig. 10), and, as you observe, it burns with the same brilliancy and lighting power as the gas produced directly from the carbide.

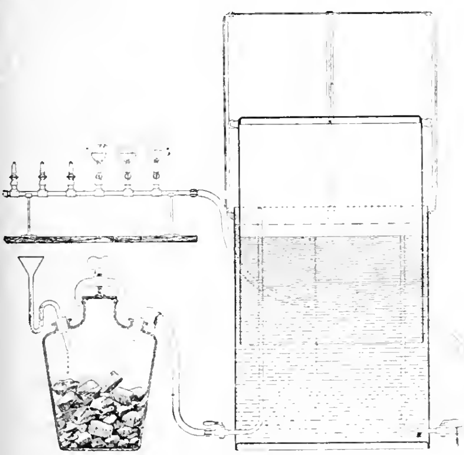

Fig. 9. Apparatus for the manufacture of acetylene from calcium carbide.

The liquefied gas contained in the small tank weighs just two pounds, and is capable of generating twenty-nine cubic feet of acetylene gas, which is at

the rate of fourteen and one-half cubic feet per pound. The gas produced by the vaporization of the liquid at a pressure, as the gauge now indicates, of forty atmospheres, passes from the tank to a reducing valve upon which the tank stands, whereby its pressure is reduced to that of a two-inch water column, as indicated on this U water gauge, and it is under this pressure that we are supplying the gas to the burners attached to the arm above. Each of the burners supplied with acetylene gas will consume, at the pressure indicated, 1 $\frac{2}{10}$ cubic feet per hour; each therefore emits a light equal to sixty candle-power; the total candle-power of the six burners in use is therefore 360, and the amount of gas consumed each hour 7 $\frac{2}{10}$ cubic feet. To obtain this result with city gas would require the consumption of at least ninety cubic feet per hour.

A ratio of 1 to 12½.

The amount of oxygen withdrawn from the atmosphere of this room by the acetylene for the same amount of light is but one-sixth of that required for your city gas; the products of combustion are therefore reduced in proportion and the air of the room is not vitiated to the same extent.

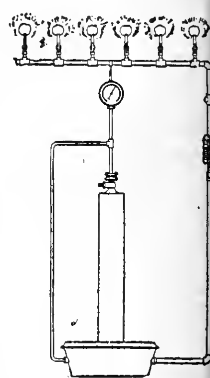

Fig. 10. Flame of liquefied acetylene.

Temperature of the flame.

From the appearance of the acetylene flame it would seem as though its temperature was exceedingly high, but recent determinations have shown that the temperature of the flame does not exceed 900° C, whereas the temperature of the ordinary illuminating gas exceeds 1,400° C. For an equal amount of light the heat developed by the combustion of acetylene gas but slightly exceeds that of the incandescent electric lamp.

An ideal illuminating gas.

We have before us to night therefore an ideal illuminating gas; its presence in a room can readily be detected by its penetrating odor; it emits more light with less heat than any other illuminating compound; it consumes less oxygen, and it can be commercially produced at less cost for an equal amount of light. Furthermore, it is capable of being stored either as a solid, in the form of carbide, or as a gas, or as a liquid; and these qualities alone are of exceptional value in its commercial application.

Utilities of acetylene,

As a solid, in the form of carbide, waste water-power throughout the world can be utilized for its manufacture, and it can be shipped long distances without material deterioration. As a gas it can be generated from carbide and applied as such; and in the form of a liquid it can be applied to all purposes of isolated lighting, such as railroad and street cars, carriages, bicycles, steamships, sailing vessels, street lighting (by placing a small tank in each lamp-post (see Fig. 2), house lighting (in both city and country), buoys, lighthouses, lanterns, and to the enriching of ordinary illuminating gas in dwellings. Its application to this latter purpose will permit the gas companies to produce a low-priced gas for heating purposes, which can then readily be enriched in each house with acetylene gas generated from a tank of the liquefied gas. To show the value of acetylene gas if applied to the lighting of your city, we will make a comparison which may surprise you. The amount of gas produced by your city works will approximate 4,000,000,000 cubic feet per

for light,

year, of say twenty candle-power. By the use of acetylene gas the amount of gas required would be reduced in the proportion of 1 to 12.5; or, 4,000,000,-000 cubic feet of city gas could be replaced by 320,000,000 cubic feet acetylene gas, representing a saving of 3,680,000,000 cubic feet of gas annually.

In addition to its value as an illuminant, acetylene gas can be used commercially for power and heating purposes; and in the form of a liquefied gas it will be invaluable for such use. Its application in this direction is however such an extensive one that we are compelled to make it the subject matter of another paper. In conclusion, we desire to thank you all for your kind attention, and especially the officers and members of the Franklin Institute for the interest they have manifested in our work.[9] fuel and heat.

[9] Regarding the cost of calcium carbide Dr. Francis Wyatt makes the following statement in the Engineering and Mining Journal of December 15, 1894: "As the actual result of its recent practice, the Willson Aluminium Company has found that it can produce one short ton of calcium carbide from a mixture of 1,200 lb. of fine coal dust and 2,000 lb. of burnt lime, and at an expenditure of about 180 electrical horsepower per hour for 12 hours. These figures are not very far from those required by theory, and they agree very closely with those given by H. Moissan, who has also produced the carbide in an electrical furnace of his own invention. It would therefore seem safe to formulate the approximate cost of production somewhat as follows for both the carbide and the acetylene:

1,200 lb. coal dust, say..............	\$2.50
2,000 lb. powdered burnt lime	4 00
180 e. h. p. from water at say 50c. per hour for 12 hours....	6.00
Labor, etc............................	2.50
Cost per 2,000 lb. Ca C_2, say............	\$15.00
Cost per 2,000 lb. C_2H_2, say............................	37.00

These figures would hold good not only for the present works in North Carolina, but at any other place where very cheap water power and equally cheap coal, lime and labor are procurable and accessible. . . . If to the estimated cost already given for the calcium carbide there be added say \$15 per ton for freight, incidentals and profit, the material for producing such a gas could be obtained at nearly all points for 30 cents per 1,000 cu. ft, ready for burning, and the convenience with which the calcium carbide can be packed and freighted, combined with the easy preparation of the gas itself in great or small quantities, at any time, should enable it, if not to be adopted for the common supply of large cities, to supply the requirements of country hotels and dwelling houses and of railway cars."

The Scientific American of March 23rd, 1895, says: "No recent chemical discovery has excited more interest than the direct production of acetylene. The calcium carbide process may properly be termed direct, for in it the carbon is first united to calcium and secondly to hydrogen, the calcium being supplied by lime and the hydrogen by water. We have given a number of papers on the subject, and the new process is now being presented in various exhibits, lectures and papers to the public. One private residence in the city has a small acetylene plant with which the house can be illuminated or which can be used to enrich the ordinary gas. If the calcium carbide can be produced commercially—and its promoters state most positively that it can be so produced—it will have a great effect upon the production of artificial light.

"Political economists, who have devoted some thought to the influence of modern scientific progress upon the condition of the world, recognize in the modern development of artificial illumination one of the most powerful instruments for the civilization of mankind. In old times the dark streets of cities were dangerous, because they were haunted by robbers who only lacked subjects because the people were afraid to go abroad after dark. When Argand invented his cylindrical lamp burner with central draught, he made one of the great steps forward in artificial lighting. The invention of plaited candle wicks, chemically treated, which as the candle burned would bend over and burn away, was considered a great discovery and achievement in its day, as doing away with snuffers. Then gas was introduced and proved to be the greatest civilizing agent for cities. When the streets were adequately lighted, crime at once diminished.

"In recent years the electric arc light has proved the best street illuminant, but gas or the incandescent electric light remains the favorite indoor illuminant. In the co-development of gas and electricity some interesting cycles or transformations of energies have resulted or have been worked out. Gas is primarily made for the purpose of giving light. When burned in the explosion gas engine it gives, from the physicist's standpoint, a far more economical result than is attainable with the steam engine. In the commercial sense the economy, owing to the high cost of gas, disappears.

"The gas engine burns some twenty feet of gas per horsepower hour, which gas represents an illuminating power of sixty to one hundred or more candles. For the production of such gas four pounds of bituminous coal suffice, which give also as side products a material amount of coke and a quantity of coal tar. If a gas engine drives a dynamo, we may get from it in incandescent lights as much or more candle power than from the original

gas burned as such, while if we use arc lamps the production would be vastly increased. In the new acetylene process a similar but more complicated cycle exists. Power is expended in producing an electric current. The current is led to an electric furnace, where it heats to an almost immeasurably high temperature a mixture of lime and carbon. The lime is reduced and gives calcium carbide. This substance is treated with water and every pound evolves five cubic feet of acetylene, enough to give 250 to 300 candle power of light for one hour.

"Thus if we know how much horsepower is expended per hour in producing a definite yield of the calcium carbide, we can compare the economy of the different cycles. As a matter of figures, it is enough to say that they come out about the same. But the new product effects other results. It diminishes the minimum size of gas holder required for the usual exigencies of gas supply. A one-foot burner gives perhaps forty candle power, or as much as ten feet of ordinary gas would give. Hence a gas holder of one-tenth the ordinary size could be used. The new gas is made without heat, and without any dangerous agent such as gasoline. Finally, when the gas is made it is a permanent one. The utter simplicity of the apparatus and process is also striking.

"One of the curiosities of the carbide is that it will not burn. It can be drawn out white hot from the electric furnace and cast in moulds. A piece can be held in a Bunsen burner without the least effect. But if a drop of water is put upon the stony substance it effervesces, aud the gas can be lighted and will burn like a piece of wood for a few seconds, until the water is exhausted. Then it goes out.

"Merely as a matter of scientific interest it is to be hoped that the commercial production will soon be accomplished. The merciless judgment of the balance sheet has wrecked many a most ingenious scientific triumph. It is to be hoped that acetylene will fare better."

SECTION V.

DIAMOND DRILL EXPLORATION.

In the session of 1894 the Legislature of Ontario made an appropriation for the purchase of two diamond drills, to be used under the direction of the Bureau of Mines for exploring mineral properties on public or private lands. The section of the Act authorizing the purchase provides as follows :

Purchase of drills for exploring purposes authorized by the Legislature.

The Commissioner of Crown Lands may, out of the moneys voted for that purpose, purchase not more than two diamond drills to be used in exploratory drilling of ores or minerals in the province, under rules and regulations to be made by the Lieutenant-Governor in Council. The regulations shall, amongst other things, provide :

1. For the control and working of the drills under the direction of a person or persons employed for the purpose by the Bureau of Mines.
2. As to the payment of freight charges where the drills are used upon mines or lands other than those owned by the Crown ;
3. As to the applications for the use of the drills and the method of dealing therewith ;
4. As to the charges for the use of the drills and for damages thereto, or wear or tear connected therewith, and otherwise as to the Lieutenant-Governor in Council shall seem meet.[1]

As soon as the appropriation was voted, correspondence was opened with the manufacturers of diamond drills in Canada, the United States and England, inviting proposals for the supply of drills of the required capacity. Practical men were also consulted as to the best make of machine for the proposed work ; but, as might have been expected, their opinions were as varied as the drills with which their own experience had been gained.

Proposals invited from the manufacturers of drills, and

Having received the proposals of manufacturers the Commissioner of Crown Lands called in the service of Mr. Wm. Hamilton Merritt as an expert and instructed him to act with the Director of the Bureau in the selection of one or two drills as authorized by the Legislature, and the following Report was the result of their joint enquiries :

W. H. Merritt and the Director of the Bureau appointed to deal with them.

REPORT ON PROPOSALS OF MANUFACTURERS.

TORONTO, July 25, 1894.

Hon. A. S. HARDY, Com'r. of Crown Lands :

SIR,—The undersigned have the honor to report that, in accordance with your instructions, they have examined and compared the several proposals made to supply the Bureau of Mines with diamond drills for use in exploring mineral properties, as authorized by the 15th section of the Act of last session of the Legislature relating to Mines and Mining Lands.

Report to the Commissioner of Crown Lands.

In considering the character of work to be done, and the hard nature of the rocks likely to be encountered by diamond drills in this province, we con-

[1] An Act relating to Mines and Mining Lands, 57 Vic. c. 16, s. 15.

cluded that it would be desirable to employ machines with capacity to bore a depth of not less than 1,000 feet, and therefore the proposals for machines of less capacity were put aside as unsuited to the work in view.

Abstracts of proposals.

Comparison of the several proposals for drills of about 1,000 feet capacity was shown by the following abstracts, ordinary equipment being as nearly as may be the same with each drill:

1. The Jenckes Machine Co. f. o. b., Sherbrooke, Que. Drill to bore 1,000 feet, and equipment of diamond bit, two blank bits, core lifter, core barrel, 200 feet drill rods, steam pump, water joint and hose, safety clamp, hoisting swivel, and set of tools to operate machine and keep bits in order	$2,600	
Add for horizontal boiler on wheels	750	
	——	$3,350
NOTE.—A revised proposal from this company, received to-day, quotes figures in detail as follows: For drill, $1,500; equipment nearly the same as above, $797.75; and unmounted 12 h.p. boiler, $320, making a total of $2,617.75.		
2. Ingersoll Rock Drill Co. of Montreal, f. o. b Toronto. Drill to bore 1,200 feet, and equipment of diamond bit. two blank bits, bit holder, core lifter, core barrel, fishing tap, water joint and hose, 200 feet drill rods, safety clamp, hoisting sheave, pump, set of tools and portable boiler on wheels		$3,400
3. M. C. Bullock Manufacturing Co., f. o. b. Chicago. Drill to bore 1,000 feet, and equipment of diamond bit, two blank bits, bit holder, core lifter, core barrel, fishing tap, water joint and hose, 200 feet drill rods, safety clamp, hoisting sheave, 75 feet steel wire rope, and set of tools	$2,500	
Add for 10 h. p. boiler on wheels and steam pump	540	
	——	$3,040
4. Sullivan Machinery Co., f. o. b. Chicago. Drill to bore 1,000 feet, and equipment of two blank bits, core lifter, core barrel, water horse with connection, 75 feet wire rope, 200 feet drill rods, sheave for hoisting rods, safety clamp and set of tools	$1,700	
Add for diamond bit	272	
15 h. p. boiler on wheels and pump	444	
	——	$2,416
5. Burton, Jones & Co. of Liverpool, in bond Toronto. Drill to bore 1,000 feet with necessary pipes, tools and accessories, and 200 carats of diamonds (exclusive of boiler)		$5,910

The Bullock drill is manufactured at Chicago, and the Sullivan Machinery Company has its head office there also, although the works are at Claremont in Sullivan county, New Hampshire; but the interruption of travel due to the railway strike made it inexpedient to visit Chicago at the time of receiving your instructions. It was therefore decided to visit the works of the companies at Montreal and Sherbrooke in Quebec, and those of the Sullivan Company in New Hampshire, these being within easy reach of each other.

Ingersoll Rock Drill Company of Montreal.

At the office of the Ingersoll Rock Drill Co. in Montreal we learned that this company does not itself manufacture diamond drills, but merely acts as agent for the Bullock Company of Chicago, and since direct proposals have been received from the latter company it was not thought advisable to treat with an agent.

Jenckes Machine Company of Sherbrooke.

At Sherbrooke we visited the office and works of the Jenckes Machine Company and were afforded an opportunity of examining a drill made by that company under the patent of the American Diamond Rock-boring Company

of New York. It is a No. 3 prospecting drill, and is the first and hitherto the only diamond drill manufactured in Canada. Its weight is 1,800 lb., the bit is two inches in diameter and it takes out a core of $1\frac{3}{8}$ inches. The machine was operated for us, but as it was not placed on a proper foundation and as the bit had not been set with diamonds, no drilling could be done. The running of the machine however seemed to demonstrate that this company is able to supply drills of good quality. The No. 3 drill is warranted to bore a depth of 1,000 feet.

Sullivan Machinery Company of Claremont, N.H.

At Claremont in New Hampshire the Sullivan Machinery Company manufactures diamond drills, as well as channelling machines for quarrying and coal mining; but the head office for sales is at Chicago. The works occupy a frontage of about 500 feet, and are commodious and well equipped. We were shown drills of all sizes made by the Company in various stages of construction, and were able to examine their parts in detail. We observed that the castings were of good quality and finish, and that facilities for supplying exact duplicates of the drills as well as of their several parts were ample. In the store-room of the works large lots of all the parts of a drill are kept in stock, so that in case of the breaking or wearing out of any part the loss could be promptly supplied.

A drill of the C class, set upon a substantial frame of hardwood and having all connections made for steam and water, was operated for us on a block of crystalline limestone. A careful examination of the machine showed that its various parts were of good material and well fitted together. The running was smooth, and the working of the hydraulic feed and the drill was eminently satisfactory. The double engines, hoisting gear and drilling apparatus are very compact and appear to be strong and durable.

The Bullock and Burton, Jones & Co. proposals.

With reference to the proposals of the Bullock Company and of Burton, Jones & Co., the prices are so much higher than the quotation of the Sullivan Company for machines of the same capacity that we do not consider it necessary at present to make further enquiries regarding them. An improvement recently adopted by the Bullock Co., whereby cores may be extracted without lifting the drill rods, appears to be deserving of investigation, but we understand that hitherto it has only been applied to drills of the largest class and for very deep borings.

The need of extra equipment and duplicate parts.

In the abstracts of proposals given above you will observe that they embrace a regular outfit with the drills, including 200 feet of drill rods, a diamond bit, and other necessary articles of equipment. But where drilling operations are carried on at a distance from the sources of supply it is important that an extra equipment should be provided, so that in case any part is broken or worn out it may be replaced out of stock and work resumed without loss of time. Extra supplies of parts most liable to wear or break, as well as of casing pipe and drill rods, are therefore a necessity for the economic working of the drill.

Three of the companies making proposals suggest certain articles of extra equipment for work in outlying localities, which when added to the proposals

with regular equipment (and embracing as nearly as may be the same items) make totals as follows :

The Jenckes Machine Co. No. 3 drill	$4,274 38
M. C. Bullock Manufacturing Co. Chief drill	3,844 00
Sullivan Machinery Co. H drill	3,322 65

The advantage therefore as regards price is clearly in favor of the Sullivan drill, and if choice was confined to those three proposals we should not hesitate to recommend acceptance of the one made by the Sullivan Company.

The Sullivan Company's C drill.

We have however examined another proposal made by the Sullivan Company under date of July 6th for a drill of the C class, and having seen the machine in operation and compared it with the machine of the H class manufactured by the same company, we think it possesses merits which entitle it to first choice. It is a stronger machine, having a capacity to bore 1,200 to 1,500 feet, while the size of the core is the same as that of the H drill, one and three-sixteenths inches diameter; from which we conclude that it will do its work faster and with less strain, without practically any additional cost for operating. The greater depth to which it will take out a core is also an important point; for although it will rarely be necessary to bore more than a thousand feet, deeper drilling may sometimes be called for, especially on fissure veins and on ore bodies of nickel, copper and iron.

The price of the C drill is $700 more than that of the H, and its weight is more by 240 lb., but these differences we believe will be more than compensated by its greater efficiency and longer life.

You will notice that the extra equipment in the proposal for the C drill is much more complete than for the H, although the regular equipment is the same for both. We consider it advisable however to procure an ample supply of equipment, and of duplicate parts of the drill and outfit most liable to wear and break, since delay occasioned by waiting until these are procured from the factory would be annoying and expensive. It is only a matter of keeping in stock articles which are sure to be required sooner or later. We suggest the addition of a long reamer and a recovering tap to the list of articles in extra equipment, at prices as quoted to us of $20 and $15 respectively.

Boiler and steam pump.

From enquiries made here we are of opinion that the boiler and steam pump might be procured from Canadian manufacturers at prices which would effect a saving of not less than $200. The rate of duty on boilers under the new tariff is 27½ per cent. and on pumps 30 per cent., and under the customs regulations the motive power used to operate diamond drills is subject to duty.

Diamonds.

As regards diamonds, these will doubtless constitute the most expensive part of the equipment and maintenance of a drill. The present selling price in Canada and the United States is about $17 per carat, and under the Customs regulations of both countries they are free. In Great Britain the latest quotation is only 42 shillings stg. or about $10 per carat, but prices vary more or less according to supply and demand, or probably as the combines which control black diamond mines are able to regulate the market. During the last fifteen years prices have ranged from $3 to $22 per carat in the United States, but we have not been able to ascertain why there should be so great a disparity in prices as appears to be the case at present in Great Britain and

the United States. It is advisable that enquiry be made from dealers in diamonds to ascertain the terms on which supplies may be obtained as they are required.

We observe that by the 15th section of the Act relating to Mines and Mining authority has been given by the Legislature for the purchase of two diamond drills. In view however of the lateness of the season, and the desirableness of proceeding cautiously in the selection of these machines, we would advise that only one drill be purchased out of the appropriation of this year. This will afford an opportunity of testing the suitability of the make and class selected for exploration work, as well as of ascertaining the demand by owners of mining lands for the employment of diamond drills. Recommendation to purchase

As a result of our enquiries, and in view of the circumstances here set forth, we recommend the purchase of a Sullivan C drill with the full extra equipment as listed in the manufacturers' proposal of July 6th, with the addition of one improved reamer and one recovering tap; saving however the items of boiler and steam pump, which may be procured at the same or lower prices from Canadian manufacturers. one Sullivan drill.

In conversation with the officers of the Sullivan Company it was stated to us that the Company is prepared to give a guarantee for the satisfactory working of their machine for a reasonable time. We advise that such guarantee be required.

Respectfully submitted,

(Signed) WM. HAMILTON MERRITT,
ARCHIBALD BLUE.

Sullivan C drill as per proposal of 6th July, with long reamer and recovering tap added	$4,339 50	
Deduct for boiler and steam pump....................	564 00	
	$3,775 50	
Add for boiler and steam pump, to be purchased in Canada, say	$480 00	
		$4,255 50

The report was approved by the Commissioner, and on 8th August a C drill was ordered from the Sullivan Machinery Company, to cost (less discount for cash), including two sets of diamonds and extra equipment, $3,611.77. Cost of drill, equipment,

A boiler of 15 h. p. capacity, mounted on wheels and with fittings complete, was purchased from the Waterous Engine Works Company of Brantford for $375 f.o.b. Toronto; and a duplex pump, 6x3x7 inches, warranted to pump against a maximum pressure of 200 lb. to the square inch, from the Northey Manufacturing Company of Toronto for $140. Tenders were invited from manufacturers for both boiler and pump. boiler and pump.

The drill was held by the Customs authorities in Toronto for six weeks, pending a decision by the Controller of Customs on the dutiable rates to be charged upon drill and outfit—although diamond drills are free under the Tariff Act. Under the Controller's ruling the charge for duty was $350.41, which was paid subject to revision. This with freight and brokerage made

the total cost of the drill laid down in Toronto $3,991.75 ; but during the present year the Customs Department has remitted $230.90 on overcharge of duty, thus leaving the net cost $3,760.85.

Rules and Regulations.

The following Rules and Regulations for the control and working of diamond drills were approved by his honor the Lieutenant-Governor on 15th September, 1894, and subsequently ratified by the Legislature:

Rules and Regulations for the control and working of diamond drills.

1. The Bureau of Mines may employ diamond drills to explore public and private lands in the province for ores or minerals subject to the following Rules and Regulations, made under authority of The Mines Act 1892, and the amending Act of 1894 :

2. The Commissioner of Crown Lands may request a skilled and competent person to examine any locality or territory of the public lands of the province, and upon receiving a report of a reasonable prospect of ores or minerals being found thereon he may require an exploration of the lands to be made with a diamond drill and may deal with them as provided in the third clause of section 12 of The Mines Act 1892.

3. The Commissioner of Crown Lands may grant the use of a drill to explore mines or mineral lands in the province owned or leased by any corporation, company, syndicate, firm, person or persons when application is made therefor in writing to the Director of the Bureau of Mines, subject to the following terms and conditions, viz. :

The applicant or applicants to give a bond in the form of schedule A hereunder, or to the like effect, with sufficient sureties, or other security to the satisfaction of the Commissioner, for payment to the Treasurer of the Province at Toronto of costs and charges for—

(1) Carrying the drill and all necessary plant to the mine or location and setting the same in place for running under proper cover ;

(2) Working the drill, including superintendence and labor, fuel and water ;

(3) Loss or breakage of bits, core lifters and core shells ;

(4) Wear or loss of diamonds, to be ascertained by weight and computed at twenty-five dollars per carat ;

(5) Other repairs of breakages and wear and tear of machinery, such sum per month as shall be estimated and certified by the mechanical manager, subject to appeal to the Director of the Bureau of Mines ;

(6) Together with an additional charge of fifty dollars per month for use of the drill from the date of report to the Commissioner that the mine or land has been shown through the use of the drill to be a valuable mineral property, where work is continued thereafter.

All such costs and charges firstly above mentioned to be paid within one month from the date of putting the drill in place ready for operation, and all other costs and charges at the end of each and every month thereafter during the continuance of the work.[2]

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[2] Schedule A.—Form of Bond.

Know all men by these presents that we of the of in the of , , of the of in the of , , and of the of in the of , are respectively held and firmly bound to Our Sovereign Lady the Queen, Her Heirs and Successors, in the several sums following, that is to say : the said in the sum of dollars, the said in the sum of dollars, and the said in the sum of dollars, lawful money of Canada, to be paid to Our Sovereign Lady the Queen, Her Heirs and Successors, for which payments well and truly to be made we bind ourselves severally and respectively and not each for the other, and our

But to encourage the exploration of mines and mineral lands and to demonstrate the utility of diamond drills in such work, it is provided that forty per cent. of the aggregate of costs and charges above enumerated (except as to the charge mentioned above in number six) shall be borne by the Bureau of Mines in 1894, thirty-five per cent. thereof in 1895, thirty per cent. thereof in 1896, and twenty-five per cent. thereof each year thereafter until the end of the year 1900. Nevertheless no part of such costs and charges shall be borne or assumed by the Bureau of Mines after a report has been made to the Commissioner by the Director and Geologist and Mineralogist of the Bureau, based upon examination of the cores of the drill and other satisfactory evidence, showing that the mine or mineral land under exploration has been shown by the use of the drill to be a valuable mineral property. Rules and Regulations.

4. Applications for use of drills will be dealt with in the order of the date of receipt; but satisfactory evidence may be required to show that there is a reasonable prospect of valuable ore or mineral being found upon a property before the granting of a drill to explore it is sanctioned by the Commissioner of Crown Lands. The Commissioner may also in writing give precedence to a later application where in the case of an earlier one there is neglect or delay in completing the preliminary arrangements, or (to prevent loss of time and extra cost of transportation) where two or more applications are from the same or a contiguous locality, but in such case he shall state in writing the reasons for giving such precedence. The Lieutenant-Governor in Council may also give precedence to an application to explore a recent and promising discovery of ore or mineral where it appears to be in the public interest that a speedy test should be made, or where substantial exploratory or mining work is being carried on, or for such other special reasons as may appear to best serve and promote the interests of mining in this province, and in such case the Order in Council shall set forth the reasons for giving such precedence.

5. The Commisioner of Crown Lands may upon the report of the Director of the Bureau of Mines suspend or terminate the working of a drill at any time, and the corporation, company, syndicate, firm, person or persons for whose benefit such drill was being used shall not have any claim to compensation on account of such suspension or termination.

6. A competent mechanical manager appointed by the Lieutenant-Governor upon such terms as to a trial and otherwise as may be deemed desirable shall have the control and working of each drill, subject to the instructions of the Director of the Bureau of Mines, and shall be responsible for the efficient

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respective heirs, executors and administrators firmly by these presents. Sealed with our seals and dated this day of , 18 .

Whereas by section 15 of an Act passed by the Legislative Assembly of the Province of Ontario in the fifty-seventh year of Her Majesty's reign, entitled "An Act relating to Mines and Mining Lands," it was provided that the Commissioner of Crown Lands might purchase not more than two diamond drills to be used in exploratory drilling of ores or minerals in the Province under Rules and Regulations to be made by the Lieutenant Governor in Council, and whereas the above-named has applied to the said Commissioner for the use of a diamond drill purchased under authority of the said section to explore for ores or minerals upon the following lands, that is to say:
of which lands the said is (*owner or lessee*), and the said Commissioner has agreed to allow the use of the said drill to the said for the purposes aforesaid under and subject to the Rules and Regulations made and approved by the Lieutenant-Governor in Council dated the fifteenth day of September, 1894.

Now the condition of this obligation is such that if the said shall well and truly pay to the Treasurer of the Province of Ontario all the costs and charges of and incidental to the use of the said drill upon the said lands to the amounts and at the times and place and in the manner prescribed by the said Rules and Regulations, and shall in all respects observe and comply with the terms of the said Rules and Regulations, then this obligation to be void, otherwise to be and remain in full force and virtue.

Signed, sealed and delivered
in presence of

Rules and Regulations.

and economic working of the drill, and for the care and safe keeping of the drill, boiler, pump, equipment and stores. He shall also be required—

(1) To have oversight of the boiler, conduct the running of the drill, set or refit the diamonds when necessary, keep an accurate daily record of the progress of borings, and preserve the cores in boxes supplied for the purpose in such a way as to show a complete and continuous section of the rocks, formations, veins or mineral deposits so explored;

(2) To superintend transportation of the plant and its removal from one site to another, to set it up in a proper manner where borings are required to be made, and to erect a sufficient cover for the drill and boiler so that operations may be carried on in any weather;

(3) To act upon the advice of the person authorized to mark the site and indicate the course of each boring and the depth to which it shall be continued, unless otherwise instructed by the Director of the Bureau of Mines;

(4) To keep an accurate and detailed account of all expenses of transportation, labor, repairs, fuel, supplies, etc., required in connection with the employment of the drill, and to make a report thereof monthly to the Director of the Bureau, and to transmit therewith all bills and vouchers for the same;

(5) To make a weekly report of progress to the Director of the Bureau while in the field, and to report forthwith any stoppage of operations due to accident or other cause;

(6) To make a detailed report to the Director of the Bureau of the operations of each year.

7. The mechanical manager shall not impart or reveal the knowledge or information acquired by him in exploring with the drill, nor exhibit the cores and cuttings of the drill, except to the Director of the Bureau of Mines, or to any person whom the Director may designate in writing, or to an authorized agent or representative of the corporation, company, syndicate, firm, person or persons for whom the property is being explored, and he shall dispose of the cores and cuttings of the drill only as he may be instructed by the Director.

8. The mechanical manager shall give a bond with sufficient sureties or other acceptable security in a sum of not less than one thousand dollars, for the faithful performance of his duties as mechanical manager and for the right care and use of the plant, equipment and stores placed in his charge.

9. The Commissioner of Crown Lands may when necessary employ a fireman to assist the mechanical manager in operating each drill at such rate of wages and allowance for expenses as may be agreed upon for the period of his employment in the field, reckoned from the day of going out to the day of returning, and the person so appointed shall in all matters appertaining to his duties be subject to the orders of the manager.

Report of Progress.

Exploring the Glendower iron mine in Frontenac county.

A number of applications were received for the use of the drill from persons and companies in various parts of the province, but following the provision of the Rules and Regulations the preference was given to the application of Mr. Joseph Bawden of Kingston. The drill was shipped to Bedford station, on the line of the Kingston and Pembroke railway, as soon as it was relieved from the customs, and it has been employed steadily since the beginning of November in exploring the iron ore deposit of the Glendower mine. This property is on the shore of Thirty Island lake in the township of Bedford, Frontenac county, about four miles from the Kingston and Pembroke railway. It had been worked for several years, beginning with 1873, a spur

line was built to connect it with the railway, and it is stated that 12,000 tons of ore were taken out and shipped to the United States. A number of openings were made, and one shaft was sunk to a depth of about 200 feet, at which point the ore was found to carry too high a percentage of sulphur. The objects of exploration with the drill were (1) to prove the extent of the ore body, and (2) to ascertain whether ore of good quality was obtainable below the horizon at which sulphur was developed. Five prospects have been completed and a sixth is in progress. For No. 1 the machine was set about 75 feet south of the shaft, and the boring was made at an angle of 80° northward; but the plan of the old workings having been lost the drill ran into the drift at a depth of 182½ feet. Time, 9 days. For the second prospect the machine was set on the northwest side of the ore deposit, 150 feet from the shaft, and the boring made at an angle of 70° south. The depth reached was 702 feet; but as the angle of dip of the vein was nearly the same as or less than the angle of the boring, and in the same direction, the ore body was not struck. Time, 46½ days. For the third prospect the machine was set 150 feet southeast of the vein, and the boring made at an angle of 70° in a line west of north to a depth of 380 feet, cutting across the ore body. Time, 27½ days. The fourth prospect was bored from the same site of the drill, but at an angle of 78° in the same line as the third, to a depth of 400 feet. Time, 29 days. This prospect was completed on 21st March. The fifth prospect upon the same site was bored at an angle of 78° in a northwest line, and at the end of April had reached a depth of 450 feet. The total depth of the five borings to that date was 2,214½ feet, and the cost of the work, exclusive of diamonds and the wear and tear of machinery, was $1,634.28, or an average of 77⅓ cents per foot. Of this amount the Bureau of Mines assumes under the Rules and Regulations $607.93, leaving $1,026.35 to be charged to the owner of the property, or an average of 48½ cents per foot.[3] Operations were continued without interruption throughout the winter, although frequently the temperature was below the zero point, and the working time was ten hours per day.

Details of the borings.

Cost of the work, exclusive of diamonds and wear and tear of machinery.

The mechanical manager reports that the borings have demonstrated the existence of a body of solid ore about 25 feet in thickness almost entirely free from sulphur, lying between bands of mixed ore. A full account of the

What the borings have proved.

[3] In the New York Engineering and Mining Journal of September 22 and 29, 1894, J. Park Channing gives the following details of actual cost per foot of boring nine holes at the bottom of a pit to an aggregate depth of 2,091 feet with a Sullivan S drill, on one of the iron ranges in Michigan.

Labor on drill	$0.606
Fireman	0.206
Fuel	0.182
Camp account	0.722
Repairs on drill, bits, core barrels, etc	0.126
Repairs on boiler and machinery and sundry supplies	0.097
Carbons	0.239
Superintendence	0.196
Total cost per foot	$2.374

The first four items of this cost per foot, together with the last item, are also included in the cost of working the Government drill at Glendower, and the comparison therefore stands as $1.91 to 77⅓ cents per foot. No information is given as to the character of the rock in Michigan. At Glendower it is crystalline limestone and granite, with bands of hornblende, and the formation in places being badly broken it was necessary to lift the rods often. In boring the second, third and fourth prospects, an aggregate depth of 1,661½ feet, the drill rods were lifted 285 times, being an average of one time for every 5.84 feet.

exploration of the Glendower mine with the diamond drill will be prepared for the next report of the Bureau.

Working of the drill.

The drill itself has given excellent satisfaction. No hitch or delay has occurred in the working of it, either through imperfect gearing, defective parts or breakages, and in every respect hitherto the representations of the manufacturers regarding it have been borne out by performance in the field.

SECTION VI.

NICKEL AND ITS USES.

In the first Section of this Report particulars have been given of the progress of nickel mining in the province as shown by the annual returns made to the Bureau. Further information on the same subject is furnished by the Trade Tables of the Dominion, which give the quantity and value of nickel exports for the four fiscal years 1890-1 to 1893-4, inclusive. In these tables the quantity is the estimated contents of fine nickel in the matte and ore shipped from the country, and quantity and value are presumably computed from data furnished by the exporters when the necessary entries are made. The following table gives the exports for the four fiscal years, classified by countries: Progress of nickel mining in Ontario as shown by the Trade Tables of export.

Exports of the fiscal years 1890-1 to 1893-4.

Year.	Country.	Quantity. lb.	Value. $	Total quantity. lb.	Total value. $
1890-1	Great Britain	847,660	30,180	5,352,043	240,499
	United States	4,504,383	210,319		
1891 2	Great Britain.	2,700,124	151,122	15,233,028	617,639
	United States	12,532,904	466,517		
1892-3	Great Britain	516,000	27,600	8,924,000	427,557
	United States	8,174,000	388,257		
	Germany	234,000	11,700		
1893-4	Great Britain	1,025,904	113,457	8,411,276	808,799
	United States	7,385,372	695,342		
Totals		37,920,347	2,094,494	37,920,347	2,094,494

The average value of nickel in the foregoing table for the fiscal year 1890-1 is $4\frac{1}{2}$ cents per lb.; in 1891-2 it is 4 cents per lb.; in 1892-3 it is $4\frac{3}{4}$ cents per lb.; in 1893-4 it is nearly $9\frac{2}{3}$ cents per lb.; while the average for the four years is $5\frac{1}{2}$ cents per lb., although the market during this period was steadily falling. The returns made to the Bureau by the companies operating in the Sudbury district (which is the only nickel producing district in the Dominion) give averages widely different from these, as may be seen on referring to page 21 of this Report. There the values are computed at the selling price per unit of metal contents at Sudbury, and the average per lb. ranges in round numbers from 14 cents in 1892 to 12 cents in 1894—counting the years from 1st November to 31st October. In another respect too the returns made to the Bureau differ widely from those of the Trade Tables of the Dominion, the latter giving the total export of the four fiscal years from 1st July, 1890, to 30th June, 1894, at the equivalent of 18,960 tons of fine metal, or over 6 per cent. in the raw ore, and the former at 10,165 tons for the five Statistics of doubtful accuracy.

years from 1st November, 1889, to 31st October, 1894, or about 3 per cent. in the raw ore. These discrepancies seem to be inexplicable on the assumption that the producers have supplied the data for computing the estimates both to the Customs Department and to the Bureau, and in the interest of the nickel industry itself it is desirable that the facts be ascertained. There can be no doubt, I think, that the values of the Trade Tables are erroneous, seeing that the average rate per pound in 1893-4 is more than double the rate of 1890-91, and that the market price of fine nickel had fallen in the interval by fully 30 per cent.[1]

The nickel industry of New Caledonia.

The only important rival of Ontario in the production of nickel is New Caledonia, in the Pacific ocean. The discovery there was made in 1863 by Garnier, who in exploring the island was struck by the special green color of the rocks, which he found to be due to coatings of veins and lumps of a hydrous silicate of nickel and magnesium. The nickel is found in serpentine, either at the contact of this rock with pockets of red clay, or near such a contact, but never in the clay itself.[2]

Mr. A. G. Charleton of England in a recent paper on the nickel industry of New Caledonia states that ore containing 7½ to 8½ per cent. nickel is worth at the port of shipment about $21 per ton, and ore with 9½ to 10½ about $25 per ton. The freight from Noumea to Havre is about $8 per ton of ore. "The principal mining companies," Mr. Charleton says, "are Le Societe Nickel and the Societe d' Exploitation des Mines de Nickel. The properties worked by the former company are all situated in this district, and in 1890 91 produced 32,000 to 33,000 tons of ore containing 7 per cent. nickel, whilst in 1892 and 1893 their output is stated to have been 40,000 tons. Besides these two companies there are several small ventures. Le Societé Nickel buys all the ore mined in New Caledonia, and owns some 60,000 hectares of mineral land on the island, but is only working 1,000, from which it is said to have cleared a net profit of more than 6.000,000 francs in one year, with a capital stock of 12,720,000 francs."

The same writer gives some account of nickel mining and treatment of nickel ore in Norway, but for the most part his information is ancient history. I am indebted to Mr. Gudbrand Henriksen of Ringerike for the following interesting particulars, which supply information on the state of the nickel industry of Norway at the present time :

The nickel industry of Norway.

"In the last five or six years," Mr. Henriksen writes, "the annual production from the mines has been 5,000 to 6,000 tons of nickel ore, with an average contents of about 100 tons nickel and 35 tons copper. Most of this has been delivered by the Evje and Ringerike mines.

"The ore is roasted in heaps and smelted to matte containing from 7 to 11 per cent. nickel. The matte is roasted in heaps and concentrated to second

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[1] In the last issued Report of the Geological Survey (1890-91) statistics of quantity and value of nickel contents of ore, matte, etc., are given for the calendar years 1890 and 1891, values being computed at average market price. For 1890 the product was 1,435,742 lb. and value $933,232, and for 1891 the product was 4,626,627 lb. and value $2,775,976. For the latter year however the price paid for nickel in the matte is said to be 13 to 21 cents per pound, or an average of 17 cents, which is the proper basis of valuation.

[2] LeNeve Foster's Text Book of Ore and Stone Mining, pp. 60, 99.

metal containing from 25 to 34 per cent. nickel. The second metal is reduced to a product containing 50 to 55 per cent. nickel and cobalt (about 2 per cent. cobalt), 15 to 20 per cent. copper, 6 to 11 per cent. iron and 18 to 22 per cent. sulphur, which is sold to the foreign refineries.

"Ringerike's nickel works is situated 58 kilometers from Drammen; and is in railway communication with that port. Evje nickel works is 70 kilometers from the port of Christianssand, and a railway from Christianssand passing by the works will be ready in the autumn of 1896.

"For the smelting is used English and partly German coke. Both at Evje and Ringerike the machinery at the smelting works is worked by waterpower.

"The Norwegian deposits of nickeliferous pyrrhotite occur as contact formations in gabbro, of the petrographical species norite."

Mr. Charleton states that the cost of producing ore of 2 per cent. grade in Norway varies from $1.67 to $3.09, averaging $2.38. One kilogram of nickel in the ore therefore costs 10.71 to 14.28 cents,—the small quantity of copper contained in the ore being reckoned free. In a few mines operated on a large scale the cost may be as low as 7.14 to 9.52 cents.

Future of the nickel trade

The future of the nickel trade is reported to be causing much interest in metallurgical circles. Since June of last year the price of the metal in England has fallen between £40 and £50 per long ton, and this heavy drop has had a serious effect on the industry. For the year ended June, 1894, the well known firm of H. H. Vivian & Co. of Swansea are said to have lost over £40,000, and the balance sheets of the great French company, Societe le Nickel, furnish an equally unsatisfactory record. The year showed, as compared with 1892-3, a deficiency of £41,760, there being £34,560 less profits and £7,200 more expenses. The profit from the sales has fallen from £80,000 to £56,000, and the interest on debentures has gone up £8,640. Out of the profit balance of £56,420 the directors propose to appropriate £26,800 on depreciation account—£6,800 to write off works in Europe, plant, machinery, etc., and £20,000 to be set aside to meet further depreciation on items where it may appear necessary to the Council. This permits of only £1,200 being carried forward to the current year.[3] The main cause of this falling of in the profits of European nickel refineries is the slump in prices, and this in a large degree is attributable to the adoption of better and cheaper processes in producing fine nickel—notably at the Orford Copper Company's works.

affected by the drop in prices.

Nickel Steel Armor Plate.

Demonstrations of the value of nickel steel for armor plate.

There is no reason to doubt that any decline is likely to occur in the use of the metal; the strong probability is that the requirements will continue to increase, as must be evident from a perusal of the statements as to its value in the papers of Mr. Sperry and Captain Jaques which follow. The early experiments made in the United States with nickel steel as armor plate not only remains unchallenged, but improvements in processes continue to demonstrate its utility for this purpose in a very remarkable degree. Why the

[3] Industries and Iron, March 22, 1895.

officers of the British Admiralty have reached an adverse decision regarding its merits does not clearly appear from any reports which they have made themselves. A few of the later tests will illustrate how strongly the new armor has entrenched itself in the opinions of competent men who have given to it a fair trial.

Test of Krupp plates.

In December of last year plates made at the Krupp works in Germany were tested at that company's proving grounds in the presence of representatives of the German Admiralty, when the results proved that nickel steel plates from 142 to 146 millimeters (5.59 to 5.75 inches) in thickness, were equal as regards resistance to any 240 millimeters (9.45 inches) plate previously manufactured at the Krupp works. No information however is given concerning the new process of treating the plate.[4]

Test of the Bethlehem Company's plate.

On 19th February of this year a 15-inch nickel steel Harveyized armor plate made by the Bethlehem Iron Company was officially tested with remarkably good results at the Bethlehem proving grounds. Two Carpenter 10-inch projectiles of 500 lb. each were fired against it at a range of 200 feet. The first charge used was 161 lb. of hexagonal powder, imparting a velocity of 1,539 feet per second, and this test was for cracking the plate. It utterly failed to do so, for the plate was penetrated only 2 inches and the chrome steel shot went to pieces, welding itself to the plate with about 3 inches projecting in the centre. The second shot was for penetration, and 241 lb. of powder were used, giving a velocity of 1,940 feet per second. Again the plate did not show the faintest sign of a crack; the projectile penetrated about 6 inches, was welded to the plate over a diameter of 18 inches, and the bulk of it was broken into minute fragments. The members of the Naval Board present declared the test one of the most signal triumphs of armor over gun and projectile ever witnessed there or abroad. Among the interested spectators was Captain Riazanine of the Russian Navy, stationed at Bethlehem to inspect the manufacture of armor plate for the Russian battle ships.[5]

Test of the Carnegie Company's plate.

A test for the acceptance of plate representing a group of 315 tons 18-inch Carnegie Harveyized armor for the battle ship Oregon was made at Indian Head on March 11th. The test plate was held in position against a 36-inch backing by 20 armor bolts of ordinary size. A 12-inch gun was used, and the line of fire for both shots was within one degree of perpendicular to the surface of the plate. The first shell fired was an 850 lb. armor piercing projectile with a charge of 250 lb. of brown powder, giving a velocity of 1,458 feet per second. The shell struck the plate half way between the top and the bottom and about 18 inches from the centre, the energy at impact being 11,000 foot tons. The shell broke up on the face of the plate, its head welding into the metal. It was estimated that the penetration did not exceed 5 inches. There were no cracks, but a slight front bulge was visible at the point of impact, and the plate scaled somewhat around the place where it had been struck. No bolts were disturbed. The shot for penetration, an 850 lb. armor piercing projectile, required a charge of 443 lb. of powder and velocity of 1,925 feet per second. This shell struck the plate about 3½ feet

[4] Industries and Iron, December 28, 1894.

[5] Industries and Iron, March 8, 1895.

from the top. After penetrating 7 inches it broke up and rebounded, leaving its head welded into the face of the plate. The plate was cracked completely in two across its width. The appearance of the metal about the point of impact was similar to that of the first shell. An examination of the metal where the plate was cracked showed it to be remarkably tough. Its performance resulted in the acceptance of the group which it represents.[6]

Prospect of further and larger uses.

The reports of these tests show that steady progress continues to be made in the production of nickel steel plate, and it cannot be assumed that the limit of possible attainment has yet been reached. No tests of all steel plate made elsewhere, whether surface hardened or not, have exhibited such powers of resistance to attack.[7] And where such demonstrations of efficiency have been given, the pertinence of the query with which Captain Jaques closes his paper will strike most people as eminently sensible.

The various other uses of nickel, some of which are referred to in the paper of Mr. Sperry, make it obvious that the demand for it will continue; and with the adoption of improved methods in separating the metal from its ore the tendency of prices is almost certain to be downward, the natural consequence of which must be its more general adoption for the purposes for which it is proven to be suitable. Nickel is yet a comparatively new metal, and it may be that much remains to be learned of its qualities and uses.

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[6] The Engineering and Mining Journal, March 23, 1895.

[7] Since this report was presented to the Legislature a report has been published of another trial of 18-inch Harveyized plate which has given the highest results hitherto attained. The test took place at Indian Head on May 1st, and the following particulars of it are given in Industries and Iron for 24th May: "The plate weighed 79,300 lb., was 16 feet 9½ inches long and 7 feet 5 inches wide, and was of tapering thickness, being 18 inches thick at the top and extending 4 feet down, where the taper to 8 inches thickness at the bottom began. The plate was attached to a backing of 36 inches of solid oak by 26 inch bolts. The first projectile was an 850 lb. 12-inch Holtzer shell, driven by 249.8 lb. of brown hexagonal powder, resulting in a velocity of 1,465 feet per second. The shell struck the plate with an energy of 12,662 foot tons. The plate was not cracked, but the nose of the projectile was pushed into the hardened metal about six inches. The second shot was fired with a projectile similar to the first one, propelled by 443.4 lb. of powder, giving a muzzle velocity of 1,926 feet per second, and the enormous striking energy of 21,885 foot tons. The penetration was 10 inches, as near as could be estimated. The head of the projectile as far as the explosive chamber was smashed on the plate, while a crack three-fourths of an inch wide was developed in the surface of the plate, extending from the top to the bottom. The plate was accepted by the Government, and then with the view of determining what its ultimate test might be under the most extreme conditions it was decided to attack it with the big 13-inch gun. Accordingly a 13-inch Carpenter shell weighing 1,100 lb., driven by 489 lb. of powder, specially adapted to this gun was discharged with a velocity of 1,810 feet per second. It had the enormous striking energy of 25,000 foot tons. While it was expected that the plate would be demolished, only a small crack 3 inches wide appeared, extending some distance from the top, and the shell after penetrating 10 inches was almost pulverized. The solid oak backing was split into kindling wood, while but one of the fastening bolts was damaged, and it is said that the other 25 would have held the plate in position on shipboard." A few weeks previously, as the result of tests with double forged plate, the U. S. Government adopted a rule which requires that armor plate for all future use shall undergo the double forging process. By this improved process 17-inch plates are reduced without reduction of weight to 14 inches after being submitted to furnace treatment, and 8-inch plates are reduced to 6 inches. This it is claimed by the New York Iron Age will be another important advance in armor manufacture, as the armor with the same weight will occupy less space as far as thickness is concerned. In a trial on 30th April of 8-inch armor plate from the Carnegie plant reforged to 6 inches, a 6-inch projectile propelled by a velocity of 2,100 feet per second on the first round was repelled by the impenetrable surface, making only what might be characterized as a mere dent, while the projectile itself went into pieces. The second round made a slight penetration, but did not go through the plate. For comparatively thin plates this result was regarded as very satisfactory; and the Ordnance officers, who are usually very conservative in accepting advances in methods of treatment and manipulation, are beginning to think that the reforging process will prove a very great advantage not only in toughening the plate by the resulting more compact condition of the grain, but will greatly lessen the bulk and consequently facilitate the propulsion of the mass of metal which constitutes the hull of the modern battle ship.

NICKEL AND NICKEL-STEEL.[8]

By Francis L. Sperry, Cleveland, Ohio.

Up to within a few years the consumption of nickel has been more directly dependent upon the available supply than that of any of the other useful metals.

Sources of the supply of nickel.

The Gap mine, in Lancaster county, Pennsylvania, has been for the last quarter of a century the only property in this country furnishing nickel in paying quantities. Its yearly output was about 300,000 pounds of metallic nickel, or nearly half the amount used annually in the United States. Foreign nickel from mines on the New Caledonia islands, in the South Pacific, found entrance into our markets as the production of the Gap mine fell off. The price of nickel was constantly maintained, and no special effort was made to extend its use. Over-production was cautiously guarded against, and all surplus metal was held by the banking-houses of the Rothschilds, who assumed the bonded indebtedness of the Société le Nickel. The opening of the Ontario nickel mines has however brought about a radical change; and nickel from the Sudbury district can be delivered in New York within four days, and in European markets within two weeks, as against two months consumed in transporting South Pacific ores. Former prices have been irretrievably smashed, and European trade-journals comment favorably on the influence which Canadian nickel has had in making lower prices and breaking the backbone of the "nickel trust."

Production and prices.

The quantity of nickel produced and the prices which it commanded may be briefly summarized as follows:

The total production of the world from 1840 to 1860 was about 100 to 250 tons yearly of metallic nickel; from 1860 to 1870, 600 to 700 tons yearly; from 1870 to 1889, about 1,500 tons yearly; in 1890, 2,000 tons; and a fair estimate for 1894 is about 5,000 tons. The metal sold for $2.25 per pound in 1860; in 1873 to 1875, for $6 to $7 per pound. From that time the price of nickel gradually declined, being $0.65 per pound in 1892, and less than $0.40 at the present time.[9] The exceedingly high prices in 1873 to 1875 were caused by the adoption of a nickel coinage by Germany and some other European nations, causing a sudden demand which exceeded the supply.[10]

Properties of Nickel and its Alloys.

As compared with iron and copper.

Nickel has similar physical properties to those of iron and copper. It is less malleable and ductile than iron, and less malleable and more ductile than copper. It alloys with these metals in all proportions. It has nearly the same specfic gravity as copper, and is slightly heavier than iron. It melts at a temperature of about 2,900° to 3,200° Fahr. A small percentage of carbon in metallic nickel lowers its melting-point perceptibly. Nickel is harder

8 A paper read at the Florida meeting of the American Institute of Mining Engineers, March, 1895, and republished with the author's sanction.

9 This was the New York quotation, where the tariff is an element in fixing the price. In the free market of London quotations ranged from 15d. to 17½d. in March, or say 30 to 35c. per pound.

10 J. H. L. Vogt, nikkel-forekomster og nikkel-produktion, Kristiania, 1891.

than either iron or copper; is magnetic, but will not take a temper. It has a grayish-white color, takes a fine polish, and may be rolled easily into thin plates or drawn into wire. It is unappreciably affected by atmospheric action, or by salt water. Commercial nickel is from 98 to 99 per cent. pure. The impurities are iron, copper, silica, sulphur, arsenic, carbon, and (in some nickel) a kernel of unreduced oxide. It is not difficult to cast, and acts like some iron in being cold-short. Cast bars are likely to be porous or spongy, but after hammering or rolling, are compact and tough. A piece of pure nickel rolled plate (A) and an untreated cast bar of nickel (B) were submitted to physical test by the writer at the works of the Carbon Iron Co., Pittsburgh, Pa., with the following results:

Test of strength of malleable nickel.

Cross-section.	Length between fillets.	Ultimate strength per sq. in.	Reduction of area.	Ultimate elongation.
in.	in.	lb.	p. c.	p. c.
A—3.11 by .045...	8	69,390	31.5	31.4
B—0.623.	2	30,985	6.5	6.5

The following table shows the properties of the metal:

Material.	Tensile strength.	Elongation.	Remarks.
	lb. per sq. in.	p. c.	
Casting	85,000	12	
Wrought nickel	96,000	14	Wrought from 2 by 4 inches to ½ inch square.
Wrought nickel, annealed.	95,000	23	Wrought from 2 by 4 inches to ½ inch square.
Rolled nickel............	78,000	10	Very hard, because not annealed after rolling; rolled from 2 to ⅛ inch.

These figures are an average of a number of tests. As there were flaws in several of the specimens, the results are lower than they otherwise would have been.

Nickel readily takes up carbon, and the porous nature of the metal is undoubtedly due to occluded gases. According to Dr. Wedding, nickel may take up as much as 9 per cent. of carbon, which may exist either as amorphous or as graphitic carbon, or in both conditions.[11] The affinity which nickel shows for carbon is manifested in a striking manner in the Mond process of refining nickel.

Magnesium as a purifying agent in nickel.

Dr. Fleitmann of Germany first discovered that the use of a small quantity of pure magnesium would free nickel from occluded gases and give a metal capable of being drawn or rolled perfectly free from blow-holes. Magnesium in nickel, like manganese in steel, acts as a purifying agent, and it improves the ductility and malleability of nickel to such an extent that the metal may be rolled into thin sheets 3 feet in width. Aluminium or manganese may be used equally as well as a purifying agent; but either, if used in excess, serves to make the nickel very much harder.

[11]Stahl u. Eisen, No. 8, 1893.

The alloys of nickel.

Nickel will alloy with most of the useful metals, and generally adds the qualities of hardness, toughness and ductility. It is commonly alloyed with copper and zinc in making the composition known to the trade as German silver, white metal, British plate, packfong or Chinese metal, argentan, electrum and maillechort, the hardness and whiteness of this alloy depending upon the percentage of nickel it contains. Nickel coins current in Germany, Belgium, Italy, the United States and Latin American countries contain 25 per cent. of nickel and 75 of copper. German silver has a considerable use in electrical fixtures and appliances, having a very high specific resistance. The alloy known as "christofle" is composed of 50 parts nickel and 50 parts copper. As yet comparatively little use is made of this alloy in the United States; abroad, it is largely employed in the manufacture of coachmakers' and saddlers' supplies, as well as for surgical instruments.

Analyses of nickel-alloys of various countries do not show very great difference in the percentage of nickel.

Analyses of nickel alloys.

—	Copper.	Nickel.	Zinc.	Iron.	Cobalt.
Berlin Alloys.	p. c.	p. c.	p. c.	p. c.	p. c.
Richest	52.00	22.00	26.00	......	......
Medium	59.00	11.00	30.00	......	......
Poorest	63.00	6.00	31.00	......	......
French Alloys.					
Tableware	50.00	18.70	31.30	......	......
"	50.00	20.00	30.00	......	......
Maillechort	65.40	16.80	13.40	3.40	......
Austrian Alloys.					
Tableware	50.00	25.00	25.00	......	......
"	55.60	22.20	22.20	......	......
"	60.00	20.00	20.00	......	......
Sheffield, England, Alloys.					
Silver white	55.20	20.70	24.10	......	......
Electrum	51.60	25.80	22.60	......	......
Hard alloy[12]	45.70	31.30	20.00	......	......
English	60.00	18.80	17.80	......	3.40
" elastic	57.00	15.00	25.00	......	3.00
Chinese packfong	40.40	31.60	25.40	2.60	......
American Alloys.					
Alloy for castings	52.50	17.70	28.80	......	......
" " bearings	50.00	25.00	25.00	......	......
Bullet-shell	75.50	24.10	.....	0.40	......
One cent coin	88.00	12.00	.....	......	......

		p. c.
Vivian & Co., Swansea, copper-nickel alloy,	Si.	.303
	Fe.	.826
	Cu.	48.49
	Ni.	50.09
Société le Nickel, Paris, copper-nickel alloy,	Si.	.186
	S.	.089
	Cu.	48.740
	Ni.	49.26
	Fe.	.610
Wiggins & Co., Birmingham, England, copper-nickel alloy,	Si.	.136
	S.	.041
	Cu.	47.68
	Ni.	49.87
	Fe.	1.228

12 Can be worked cold.

Steel and Nickel Steel.

It will hardly be questioned that scientific research is directed most energetically at the present time upon the art of uniting elements in such proportions that they may be more serviceable than in their pure state. The limit of ultimate strength in the practical application of pure metals has about been reached. The practical introduction of steel into general use has made a new era in manufactures, and "steel is only modified iron; the difference in its state from a condition as soft as copper to one as hard as glass being due to the modifications of carbon." Up to recent times the distrust of steel was so great that marine and civil engineers were afraid to use it. In the early days of the Pennsylvania railroad its steel rails were imported from England, bent to the curves of the roadbed. As a superior metal for cutlery and tools it brought a fancy price of 36 cents per pound. To-day our battleships are sheathed with thousands of tons of the best steel, and 800 tons are used yearly in the manufacture of steel pens. Carbon-steel was a great improvement over iron, and the use of nickel in steel is found, in all cases in which careful investigation has been made, to mark a further improvement in the manufacture of steel. A German authority has recently observed that, considering the mutual affinity of nickel and iron, as shown by the presence of nickel in meteoric iron, it is remarkable that the example of the handiwork of Nature had not been copied before this.

Improvement in the quality of steel, and extended uses of it.

In a paper read before the Iron and Steel Institute, Mr. James Riley, manager of the Steel Works of Scotland, says:[13]

Riley's testimony to the value of nickel steel.

> "If the engineers of those stupendous structures (the Forth Bridge and the Eiffel Tower) had had at their disposal a metal of 40 tons (ultimate) strength and 28 tons elastic limit, instead of 30 tons strength and 17 tons elastic limit in the one case, and say 22 tons strength and 16 tons elastic limit in the other, how many difficulties would have been reduced in magnitude as the weight of material was reduced!"

Mr. Riley's paper was the first to present publicly the merits of nickel steel, and attracted much attention.

Just about that time the Ordnance Bureau of the United States Navy Department was seeking the best type of armor-plate for the new battleships, and the superior qualities of nickel steel were brought to the attention of the department. Secretary Tracy authorized a comparative trial of three armor-plates forged at the largest steel-works in France and England, and representing the best types of simple steel, nickel steel and compound (hard and soft) steel armor plates. The result of this trial, in September, 1890, indicated so strongly the superior merits of nickel steel that Congress was justified in granting an appropriation for the purpose of purchasing the necessary quantity of nickel to continue experiments. These experiments were uniformly successful, and the Navy Department adopted nickel steel for armor plate, and wherever possible in the work of the Ordnance Bureau. Nickel steel armor of the best quality is now regularly produced by two of the large steel works of Pennsylvania, the Bethlehem Iron Co. and Carnegie, Phipps & Co., which have special facilities for handling this class of work. The former concern forges all its plates, while the latter employs rolls.

Tests of its utility for armor plate in the United States.

[13] Alloys of Nickel and Steel, Journ. I. and S. Inst., No. 1, 1889, p. 54.

Harveyized nickel steel.

The Harvey process of hardening the face of nickel steel armor by cementation to the depth of several inches, with subsequent water-hardening, is an important advance in making nickel steel armor still more effective.

The type of armor plate used by the British Admiralty is a compound plate made up of a hard steel face and soft steel backing. They considered the question of the best armor for their battleships as settled in 1878, when they adopted this type of armor plate. Comparing the relative depth of penetration in the Harveyized nickel steel, all steel, compound and soft steel armor plates, the ratio of superiority in favor of the Harveyized nickel steel plate is as follows, in the order named :

Relative penetration.	Kind of armor plate.	Relative resistance.
1.	Nickel steel, Harveyized.	1.
1.64	All steel.	0.609
1.75	Compound.	0.572
2.2	Soft steel.	0.455

So that for equal power of resistance there can be a saving of 43.8 per cent. in weight in favor of the Harveyized plate over the compound plate.[14] The ordnance trials at the Indian Head proving grounds are as severe as any in the world ; and it is with pardonable pride that the Bureau of Ordnance of the Navy regards the placing of an order for nickel steel armor plate by the Russian government with the Bethlehem Iron Company as an acknowledgment that we have to-day the material and facilities, and are forging in this country armor and projectiles that have no superior in the world.[15]

Krupp of Essen is furnishing for vessels of the "Brandenburg" class in the German navy nickel steel armor made on a new system. The plates are $5\frac{1}{2}$ inches thick, and show a resistance equal to plates of $9\frac{3}{4}$ inches made by the old system.

The French government uses an armor plate containing 0.4 per cent. carbon, 1 per cent. chromium and 2 per cent. nickel.

Nickel furnishes toughness and chromium hardness. It is in the highly desirable qualities of extreme toughness and elasticity that nickel imparts valuable properties to steel, increasing its resistance to shocks and hindering crystallization.

The Bureau of Steam Engineering, United States Navy, has had the two intermediate line shafts of the Iowa and the two propeller shafts of the Brooklyn made of nickel steel by the Bethlehem Iron Company. The line shafts are $15\frac{3}{4}$ inches outside and $9\frac{3}{4}$ inches inside diameter, while the propeller shafts are 17 inches outside and 11 inches inside diameter ; the walls being in both cases 3 inches thick. The government specifications require a

[14] See Stahl u. Eisen, No. 4, 1893.

[15] See article "British Armor and Ordance," London Engineer, March 23, 1894.

tensile strength of 85,000 lb. and 50,000 lb. elastic limit. Six test pieces from one of the propeller shafts of the Brooklyn gave the following results:

Nickel steel propeller shaft for U. S. ship Brooklyn.

Hollow-forged, oil tempered, rough-machined. Outside diameter, $17\frac{1}{8}$ inches; inside diameter, 11 inches; length, 38 feet $11\frac{3}{8}$ inches; weight, 19,112 pounds. Test bars cut from this tube gave the following results:

Dimensions of specimens.	Tensile strength.	Elastic limit.	Elongation.	Contraction.	Fracture.
in.	lb. per. sq in.	lb. per sq in.	p. c.	p. c.	
0.496 by 2	94,185	58,995	26.4	60.83	Dense gray lipped.
0.497 by 2	94,245	60,770	25.55	60.58	"
"	93,215	58,740	25.8	61.33	"
"	93,730	60,770	25.8	59.81	"
0.498 by 2	92,410	59,550	28.0	60.74	"
"	90,350	56,470	28.0	60.74	"

It is to be noted that the elastic limit of this shaft is about equal to the tensile strength of a shaft made of ordinary mild steel, while the elongation and contraction of area are nearly the same.

Tests of hollow nickel steel and solid soft steel shafts,

A comparison of the strength of the nickel steel shafts of the U. S. vessels Brooklyn and Iowa, within their elastic limits, with that of solid shafts of the same sectional area made of soft, simple steel, having an elastic limit of 30,000 pounds per square inch, and also a comparison of their weights per linear unit with that of solid soft steel shafts of equal strength, may be of interest. The following table gives the results of calculations made by Prof. Mansfield Merriman, Lehigh University, Pa.:

Case I. Comparison of three steel shafts	Propeller shaft U.S.S. Brooklyn. Hollow. Outs. diam. 17 inches; ins. diam. 11 inches. Nickel steel, e. l. 50,000 lb per sq. in.	Solid shaft, same (approximate) sectional area. Diameter 13 inches. Simple steel, e. l. 30,000 lb. per sq. in.	Solid shaft, same strength under applied loads or horse-powers. Diameter 18.90 inches. Simple steel, e. l. 30,000 lb. per sq. in.
Area of section, square inches..	131.95	132.73	280.55
Weight per yard, pounds	1,346	1,354	2,861
Comparative strength under applied loads in flexure, or under applied horse-power in torsion....................	307	100	307
Load, in pounds, at middle of a span of 12 feet on two supports, which strains to one-half elastic limit	276,200	89,900	276,200
Length of beam on two supports, which is strained by its own weight to one-half elastic limit	121 ft. 6 in.	77 ft. 6 in.	83 ft. 4 in.
Horse-power transmitted at 50 revolutions per minute when strained to one-half elastic limit........................	15,780	6,130	15,780

Case II. Comparison of three steel shafts.	Intermediate line shaft U. S. S. Iowa. Hollow. Outs. diam. $15\frac{3}{4}$ inches; ins. diameter $9\frac{3}{4}$ inches. Nickel steel, e l. 50,000 lb. per sq. in.	Solid shaft, same (approximate) sectional area. Diameter $12\frac{3}{8}$ inches. Simple steel, e.l. 30,000 lb. per sq. in.	Solid shaft of same strength under applied loads or horse-powers. Diameter 17.71 inches. Simple steel, e.l. 30,000 lb. per sq. in.
Area of section, square inches.	120.17	120.28	246.34
Weight per yard, pounds	1,225	1,227	2,513
Comparative strength under applied loads in flexure, or under applied horse-power in torsion	293	100	293
Load which, at middle of a beam 12 feet in span on two supports, causes strains equal to one-half elastic limit, pounds	227,200	77,500	227,200
Length of beam on two supports which is strained by its own weight to one-half elastic limit	115 ft. 6 in.	75 ft. 9 in.	80 ft. 8 in.
Horse-power transmitted at 50 revolutions per minute when strained to one-half elastic limit	12,980	4,430	12,980

and their relative merits.

The hole in a hollow forged simple steel shaft of $15\frac{1}{2}$ inches outside diameter is 7 inches. Nickel steel hollow forged shafts having the same outside diameter may have a hole of $11\frac{3}{4}$ inches diameter. But for fear of any possible chance of buckling, the hole is made $9\frac{3}{4}$ inches in diameter. The propeller shafts of the American Line steamers St. Louis and St. Paul are of nickel steel; they will stand $42\frac{1}{2}$ tons breaking strain per square inch, and show 28 per cent. elongation and 50 per cent. reduction of area per square inch. The shaft of the Iowa will stand 45 tons breaking strain per square inch, while $33\frac{1}{2}$ tons is the limit in ordinary steel shafts.

"Here then is a material admirably suited to the shafting and engine forging required by the marine engineer of modern high service engines, and it is believed that as its merits become known its use will be widely extended. In the highest development of the modern marine engines, reduction of weight of all parts is of prime importance. This can only be accomplished by reducing sectional area. On the other hand, outside dimensions cannot be usually reduced without sacrificing necessary stiffness. We are therefore led to removing the metal along neutral axes, or, in other words, to the use of hollow forging. It is evident that to farther reduce weight, as well as to increase the absolute strength of parts, the designer of marine engines needs a stronger material than that now employed; that is, a material having a greater elastic limit, but at the same time possessing such a degree of toughness as to insure resistance to sudden strain and shock. Simple steel strengthened and toughened by tempering and annealing will show, in specimens cut from the center of sections, say 3 inches to 6 inches thick, an elastic limit of about 45,000 pounds per square inch, an elongation of about 23 per cent., and a contraction of area of from 50 to 55 per cent. A farther and very pronounced improvement in strength and toughness can be obtained by the use of nickel steel, tempered and annealed as above described. The use of nickel allows a reduction of carbon, makes the steel more sensitive to temper, and facilitates the tempering of irregular shapes. Specimens from nickel-steel forgings, tempered and annealed, will show uniformly an elastic limit of from 50,000 to 55,000 pounds per square inch, an elongation of 23 per cent. and above,

in specimens 2 inches long by ½-inch diameter, and a contraction of area of from 55 to 60 per cent. In cases where, owing to thickness of sections and irregular shape, tempering is not advisable, nickel steel will still show a higher combination of elasticity and toughness than any other material known, under the same conditions."[16]

Other Uses of Nickel Steel.

A complete set of nickel steel forgings for an 8-inch gun has been made by the Bethlehem Iron Company for the Bureau of Ordnance, United States Navy, and is now being assembled at the Washington navy yard. The average physical qualities obtained in these forgings in transverse specimens were: Nickel steel for ordnance,

—	Tensile st. ℔. per sq. in.	Elastic limit ℔. per sq. in.	Elongation p. c.	Contraction of area p.c.
Tube	93,200	58,300	21 2	42.0
Jacket	99,900	60,000	20.4	45.9
Hoops	109,100	68,200	20.5	46.9

Test specimens were 2 inches long by ½-inch diameter. Comparing with the average of qualities usually obtained in corresponding navy gun forgings made of simple steel, the tensile strength shows an increase of about 10 per cent., with an increase in elastic limit from 22 to 28 per cent., while the contraction of area and elongation are but slightly reduced.

The Bureau of Ordnance found while experimenting that two small-arm barrels showed greater endurance than others. They were respectively of a very high-carbon steel and a steel containing about 4½ per cent. of nickel. The latter was fairly easy to machine, while the high-carbon steel was almost intractable. Consequently the Bureau decided to adopt nickel steel for its small-arm barrels. The great excellence attained by the Greener gun is attributed to the use of nickel steel barrels containing 2.75 per cent. of nickel and 0.2 per cent. of carbon small arms,

It is evident that, besides the application to which nickel steel is being put in armor plate, gun forgings and marine shafting, there is a still wider field open to its use for structural steel, heavy castings, car-couplers, car-wheels, boiler-plates, small pinions and knuckles, shear-knives, bicycle-spokes, gears for motors, and all varieties of work demanding hardness, toughness and malleability. structural steel, etc.

Plates of iron or steel and nickel, when laid together and heated to welding temperature, may be rolled out into thin plates with a continuous nickel surface on both sides, or iron or steel on one side and nickel on the other. The union of the two metals is not merely a welding, but is of the nature of cementation, an actual alloy being formed to some depth below the surface of contact. There is a steam vessel in New York harbor sheathed in part, as an experiment, with this material, fastened with iron nails. After eight months constant service the iron nails have corroded away, and all of the bottom except the nickel sheathing is corroded and foul, while the latter is as Cementation of iron and nickel plates.

[16] R. W. Davenport, Vice-President Bethlehem Iron Company, Trans. Nav. and Marine Engrs., vol. 1., 1893.

clean as when first put on. If nickel nails were used, it would seem as if nickel sheathing, or sheet nickel, would make an ideal sheathing for all salt-water craft. This material is also used for lagging steam-cylinders, feed-water heaters, etc. It takes a beautiful polish, and is stronger than brass or copper.

Use of nickel steel in powerful electric machinery, and

The Niagara Falls Power Company has recently installed four 5,000 horse-power electric generators coupled to turbine water wheels. In this type of generator the periphery of the large rotating field travels at the rate of nearly two miles per minute. The bobbins are secured within a ring of nickel steel that is forged without a weld, having an outside diameter of $139\frac{3}{8}$ inches; inside diameter, 130 inches; width, $50\frac{3}{4}$ inches; weight, 28,840 pounds. This ring of nickel steel is extremely light for its strength, and resists the centrifugal forces of this large field, while adding but little to its weight.

for steam boilers.

The Bureau of Steam Engineering, United States Navy, has decided to put nickel steel boilers in the cruiser Chicago, which is shortly to undergo repairs.

Nickel steel wire for marine service.

Nickel steel containing as much as 30 per cent. of nickel may be drawn into wire as easily as ordinary steel. Wire of this class, containing sufficient nickel to make the non-corroding qualities of the metal prominent, is especially adapted for hawsers and cable service in salt water. A sample of nickel steel wire containing 27.8 per cent. nickel and 0.40 per cent. carbon, used as torpedo defence netting by the United States Navy, gives the following physical test:

Diam. cross sec. inch.	Area of cross sec. sq. inch.	Reduced diameter. inch.	Reduced area. sq. in.	Con. area. p. c.	Elong. in 2 in. p. c.	Load in lb.	Breaking strain per sq. in. in lb.
0.116	0.01057	0.106	0.0088	16.5	6.25	2,100	198,700

The high tensile strength of this wire, with the comparatively small reduction in elongation and contraction of area, indicates extreme toughness; and at the same time it is not acted upon by salt water, so that it admirably answers the requirements of marine service.

Flange Steel.

Tests of flange steel with and without nickel.

The Cleveland Rolling Mill made some flange steel for the Canadian Copper Company, with and without nickel, for the purpose of making comparative tests of their physical qualities. The results are given in the table on the next page.

This nickel steel shows an average increase of 11,400 pounds per square inch, or about 31 per cent. in elastic limit, and an average increase of 10,400 pounds per square inch, or about 20 per cent. in ultimate strength, without any perceptible effect upon the ductility, as evidenced by the percentage of elongation and contraction of area.

The Canadian Copper Company at its works at Brooklyn near Cleveland, Ohio, made a series of experiments on nickel steel with varying percentages of nickel and carbon in an improvised acid bottom open hearth furnace. The heats amounted to about 1,000 pounds of metal, made out of washed low phosphorus pig and high grade Bessemer ore. Nickel in metallic form was charged into the bath about one and one-half hours before tapping. Difficulty

Tests at the Canadian Copper Company's works.

Comparative tests of nickel steel and best soft flange steel.

—	Charge. lb.	Reduction of area. p.c.	Elongation in 8 inches. p.c.	Elastic limit. lb. per sq. inch.	Ultimate strength. lb. per sq. inch.
I. Nickel steel. Containing C., 0.08; Mn., 0.36; P., 0.045; S., 0.038; Ni., 2.69.	Basic scrap, 9,000; low - phosphorus pig, 9,000; 80 per cent. ferro, 165; 97 per cent. nickel, 540.	53.	23.25	....	64,080
		53.3	26.	47,100	66,370
		56.3	25.	44,700	66,000
		45.1	24.5	47,400	67,100
		54.4	26.	47,300	64,800
		49.7	23.75	48,900	66,200
II. Soft steel. Containing C., 0.10; Mn., 0.27; P., 0.048; S., 0.039.	Basic scrap, 9,000; low - phosphorus pig, 9,000; 80 per cent. ferro, 160.	45.6	26.	35,700	55,500
		45.8	26.	35.500	54,600
		52.9	27.5	32,800	53,900
		61.8	32.	34,060	52,500
		63.	27.	35,500	53,700
		63.	26.	37,900	56,500

was experienced in controlling the heat, and other adverse conditions were encountered on account of the limited scale and lack of facilities in managing such a small furnace, which rendered it impossible to make steel of a uniform grade and show the degree to which a definite percentage of nickel in steel would be influenced by varying percentages of carbon, and vice versa. Still the results of the physical tests of this steel may be of interest. The test pieces were all taken from the center of the ingot, hammered to one and one-half inches square, and then turned down to a diameter of $\frac{5}{8}$-inch, with two inches between fillets, which were $\frac{7}{8}$-inch in diameter and threaded:

No. of specimen.	Carbon. p.c.	Nickel, p.c.	Ultimate strength, lb. per sq inch.	Reduction of area, p.c.	Elongation, p.c.	Length, inches.	Fracture.	Hardness in lathe.
14	0.16	3.35	102,800	29.1	15.0	2	Silky.	Soft, UnA.
14	0.16	3.35	100,650	48.1	27.0	2	Silky.	Soft, A.
19	0.19	2.62	141,100	24.8	11.9	8	Gray.	Hard, Drawn.
13	0.22	2.05	88,880	34.6	20.5	2	Gray.	Easy, UnA.
13	0.22	2.05	84,650	55.4	31.5	2	Gray.	Easy, A.
13	0.22	2.05	83,040	58.2	25.1	8	Gray.	Easy, Drawn.
15	0.31	3.40	109,100	24.4	17.0	2	Gray.	Easy, UnA.
15	0.31	3.40	100,800	49.2	26.0	2	Gray.	Easy, A.
15	0.31	3.40	98,120	44.4	20.0	8	Silky.	Easy, Drawn.
41	0.51	4.93	127,075	27.1	16 0	2	Crystallized.	Hard, A.
24	0.54	3.20	131,200	12.7	10.5	2	Gray.	Hard, A.
24	0.54	3.20	134,400	36.7	14.3	8	Gray.	Hard, Drawn.
29	0.96	3.10	151,880	12.9	8.0	8	Gray.	Hard, Round.
34	0.91	3.10	138,000	22.3	9.88	8	Gray.	Hard, Round.

This steel was quiet in the moulds after tapping, set quickly without piping, and the ingots were smooth and clean. They were submitted to the same treatment in the hammer shop and rod mill as is given to ordinary steel. Through a mistake in getting numbers changed, the bars drawn through the rolls of the rod mill received an extra annealing heat. The conditions of the tests were as near alike as possible; the only exception being that the rods were pulled in the testing machine[17] as they came from the $1\frac{1}{8}$-inch rolls, in 8-inch lengths, while the other test specimens were 2 inches long and $\frac{5}{8}$-inch diameter.

The specifications of the Baltimore and Ohio railroad for steel tires, and the U. S. Navy Bureau of Steam-Engineering for crank and propeller shafts, connecting and piston rods and ordnance, are as follows:

Specifications of Baltimore and Ohio railroad.

Grade.	Carbon, p.c.	Tensile strength, lb. per sq. in.	Elongation in 4 inches, p.c.
I.	0.50 to 0.60	105,000	16
II.	0.60 to 0.70	115,000	14
III.	0.68 to 0.78	125,000	10

Grade I. is for passenger engine tires, outside diameter, 60 inches; grade II., for consolidation, mogul, etc., outward diameter, 45 to 60 inches; grade III., for switching engines, car wheels, and all tires less than 46 inches in outside diameter.

A variation of 10,000 pounds in tensile strength above or below the above figures is permitted.

Specifications of the Bureau of Steam Engineering, U. S. navy.

——	Tensile strength, lb. per sq. in.	Elongation in 2 inches, p.c.	Contraction of area, p.c.
Propeller shafts	85,000	23	....
Crank shafts	58,000	28	....
Connecting rods	65,000	25	....
Piston rods	65,000	25	....
Ordnance	85,000	18	35

An advantage of greater strength with same weight, or equal strength with less weight.

It goes without saying that, where other conditions are equal, soft or low carbon steel possesses advantages over hard or high carbon steel, as it is easier to machine, and (what is of greater importance) may be submitted to much rougher treatment, because it is not subject to the dangerous internal strains of hard steel. It is in this respect especially that nickel steel, having the superior qualities of soft steel, fulfils the requirements of service sought for in hard steel, and offers to engineers the advantages of a material which will give greater strength with same weight, or equal strength with less weight, than any other at their disposal. Comparing the accepted standard of mild steel with nickel steel having approximately the same carbon contents:

17 Otis Steel Company's Olsen machine.

——	Tensile strength, lb. per sq. in.	Elongation, p.c.	Contraction of area, p.c.
Ordinary steel....	65,000	23 in 8 in.	48.0
No. 13 nickel steel (2.05 per cent. nickel)..	84,650	31.5 in 2 in.	55.4
No. 14 nickel steel (3.35 per cent. nickel)	100,650	27.0 in 2 in.	48.1

We have here nickel steel, containing less than 0.2 per cent. carbon, and 3.35 per cent. of nickel (annealed), that more than meets the specifications of the Navy Department for ordnance, shafting, etc., and of grade I. for steel tires on the Baltimore and Ohio railroad.

For grade III., requiring high grade steel, we make the following comparison with nickel steel, annealed, containing 0.20 per cent. less carbon than the required carbon in plain steel :

——	Tensile strength, lb. per sq. in.	Elongation, p.c.
B. and O. railroad steel tires, grade III..... .	125,000	10 in 4 in.
No. 24 nickel steel...........................	134,000	14 in 2 in.

By 2.0 per cent. of nickel (No. 13) the tensile strength of mild steel is raised 30 per cent., and by 3.35 nickel (No. 14) 41 per cent., without any appreciable change of elongation or reduction of area. "The presence of 4.7 per cent. of nickel increases the tensile strength 35 per cent., and the elastic limit 75 per cent., while the elongation and contraction of area is practically the same."[18]

Value of a high percentage of nickel in the alloy.

In reviewing the results of these experiments, corroborated by the experience of others, it is found that better results are obtained by using more rather than less than 3 per cent. of nickel. The tensile strength and elastic limit of steel increases with the percentage of nickel, up to the point of extreme hardness in machining, and the percentage of carbon has everything to do in raising or lowering this property of nickel steel, as much as in ordinary steel.

Torsion tests at Cleveland.

Torsion tests of these specimens were made by the Standard Tool Co., Cleveland, Ohio, as follows :

No. of specimen.	Carbon, p c.	Nickel, p.c.	Torsion-breaking point in lb. per sq. in.	Degrees of twist in 3 in. before breaking 360°=1 full twist.
14......	0.16	3.35	2,325	360 ....
19.......	0.19	2.62	2,150	130 Split.
13.	0.22	2.05	2,434	240 Twisted off.
15.......	0.31	3.40	1,807	355 ....
41.......	0.51	4.93	2,200	120 ....
24.......	0.54	3.00	1,200	60 Split.
29.	0.96	3.10	1,700	60 Split.

[18] Riley's experiments.

The specimens in these torsion-tests were $1\frac{1}{4}$ inches square. A number of the specimens were found to be checked and laminated in structure.

Cold-bending test.

In a cold-bending test of a specimen $2\frac{1}{2}$ by $2\frac{1}{2}$ inches (full thickness of wall of forging), 18 inches long, under hydraulic press through 180°, the ends met within $\frac{1}{2}$ inch; the greatest distance between sides was $\frac{7}{8}$ inch. There was only one slight crack, in one corner on the inside of the bend.[19]

General conclusions.

The percentage of nickel in all the government work herein referred to is 3.25 per cent., with carbon at about 0.2 per cent. It is not improbable that familiarity with working and cheapening the cost in manufacture will permit the percentage of nickel to be considerably increased above this figure to good advantage. It has been the practice in this country to charge the nickel into the furnace in the form of nickel oxide enclosed in sheet iron boxes. In other countries pig or ferro-nickel is used. Some steel plants use metallic nickel, which offers this advantage over the oxide that less nickel slags off. The best results are obtained in the basic open-hearth furnace. Several of the Pittsburgh steel works use nickel as an alloy for steel, but are not yet prepared to make a special feature of nickel steel castings outside of government work. The Bethlehem Iron Compnay, having enlarged its plant, has special facilities for making nickel steel in any desired form or size for the general trade, besides taking large government contracts.

It is obvious from the foregoing data, which briefly summarize the present status of the metallurgy of nickel, that the field for the use of nickel is one of magnitude, and that the era of its development has only just commenced.

NICKEL STEEL: ITS SPECIAL VALUE FOR ARMOR.[20]

By Captain W. H. Jaques, Ordnance Engineer, New York City.

In responding to a request to prepare an article on some engineering question of importance for publication in a British journal, I take pleasure in selecting one that appears to have been neglected in Great Britain. Whether the neglect is due to omission or commission may be difficult to decide.

An objection to nickel that is rapidly disappearing.

To me as an American it appears as if the neglect was intentional, for the objection to the high price of nickel seems to be rapidly disappearing, and the feeling that British metallurgists cannot secure as good results with nickel as have been obtained in the United States, Germany and France ought to be removed by local accomplishments, as it certainly can be under the advice of those who have already obtained such favorable and useful results.

In relation to the price of nickel, the last report of the directors of H. H. Vivian & Co., Limited, gives ample data.

Experience of the H. H. Vivian Co.

"At the commencement of the twelve months," it reads, "the selling price of nickel was about 1s. 9d. per lb. net, while at the end it had been sold as low as 1s. $3\frac{1}{2}$d. per lb. The loss on the nickel and cobalt trade of Hafod Isha Works was £15,102 10s. $7\frac{1}{2}$d., of which £13,340 15s. 11d. is entirely attributable to the reduction in the value of stocks. The difference between

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[19]Laboratory of Lehigh University.

[20]Published in the Engineering Review of London, Eng., February 20, 1895.

the two sums is due to constant fall in prices of current sales during the year. A loss of £1,299 15s. on the Murray mine arises from the value of the nickel product being credited at less than cost, although this mine has produced, and is producing, at a low rate. A loss of £3,764 12s. 1d. on the Evje mine is very vexatious. When the directors took a lease of this mine the value of nickel was about 2s. 9d. per lb., at which it was capable of working profitably. The fall of nickel to prices previously mentioned upset all calculations, and converted the anticipated profit into a loss."

No doubt some companies and some nickel mines will have to be sacrificed in the progress. But did this not occur to the iron industry when steel so completely replaced iron? What sadder evidence of this than the black Birmingham district? And to how many other industries would this apply?

The best and surest way of reducing prices.

The best and surest way to reduce the price of nickel is to make a commercial demand for it strong enough to encourage its production in the various forms in which it can be most successfully employed. Take aluminium for example; who would have thought five years ago that this metal could be sold for 40 cents a pound. To-day makers will be glad to sell it for that, and no doubt before this new year is finished users of it will be able to obtain it for half that price.

In regard to supply, the Canadian mines alone can more than meet the demand. In fact it has been reported that an American company supplied last year 70 per cent., if not more, of 1894's consumption by the entire world.

The popular clothing of armor to-day is carbonization.

Techincal value of carbonization.

In regard to its technical value, and the very prominent part that nickel is now taking in the development of steel, I cannot better express my opinion than by repeating the views I presented at the last meeting of the American Society of Naval Architects, and which have been published or quoted in various technical journals. They are given here to emphasize the recognition of a most valuable metal, not only for use in the production of armor, guns and other war material, but in boilers, plates, shafting, piston connecting and hammer-rods, where better physical and wearing qualities are demanded.

The British makers have given up the compound type to which they so tenaciously held, and all European manufacturers of armor have adopted the carbonized all-steel, using more or less carbonization or surface hardening in accordance with their own special views, and employing a variety of methods to secure the surface hardening. Great Britain has acknowledged our supremacy in the armor question, and partially imitated our methods; but, for some reason not yet publicly explained, the employment of nickel in armor has been officially announced as an unnecessary increase in the cost of its production. Considering the benefits that its use has demonstrated in steel for many other purposes as well as armor, it is difficult to accept this decision on the part of the British Admiralty.

The decision of the British Admiralty questioned by other experiences.

The attempts to demonstrate the value of nickel in steel have been very unfortunate in England, and the question naturally arises, Why is nickel steel so expensive as to preclude its use there? The United States' steel workers have had better success with nickel than even French makers, although to Mr. Schneider, of France, belongs the credit of introducing nickel in steel.

Krupp's nickel steel plates have shown splendid results ; while Bethlehem, Carnegie, St. Chamond, and even Brown and Vickers, have given many practical evidences of the value of nickel in armor steel. Perhaps if Vickers had introduced the right proportion of nickel in the composition of his plate tested at Texel in August of 1893, and if it had been properly worked and treated, he would have won on resistance and not lost on brittleness.

The tests of thick armor which excited the most interest during the past year, and carried with them the greatest commercial risk were the 17-in. and 18-in. nickel steel carbonized plates for the United States battleships. While the most resisting *individual plate* tested was *nickel steel carbonized,* the ballistic tests failed to demonstrate the limit of the dimensions to which the carbonization process could be advantageously applied.

On the contrary, in every case where nickel was employed in the United States, Germany and France, excellent results have been obtained. Uniformity, which is one of the characteristics most to be sought for, appears to be best obtained in the nickel steel type. If this is secured, even at a slight reduction of ballistic resistance, the certainty of having a product of uniform quality is a marked advantage.

In connection with chrome very good results have also been obtained. The large quantity of nickel used by the St. Chamond Steel Works is another very practical demonstration of the estimation in which it is there held. [21]

The placing of a contract for armor in the United States by Russia is a revolution from the usual methods and influences of the European makers. While the remarkable success which Bethlehem secured while I was connected with the manufacture there had much to do with this result a most important element of the transaction was the decision to use *nickel steel* plates, *not* carbonized ; for the order was only secured by a serious cut in prices, the contract being merely for the belt armor of two Russian battleships (600 tons for each of 15-in. taper 8-in.): a large remaining tonnage is left to be supplied by other makers.

The decision of greatest importance therefore is the estimate that Russia has placed upon the use of nickel.

The value of Riley's work.

Not only English but other scientists are familiar with Riley's work demonstrating the value of nickel in steel. His experiments were certainly favorable enough to induce any steel maker to make use of this new, and, for many purposes, more valuable steel, unless personal sentiment or influences were stronger than prospective commercial and technical worth.

Other nations have made good use of the results Riley published ; large nickel properties were bought, syndicates were formed, even Great Britain

[21] The N. Y. Engineering and Mining Journal of March 30, 1885, refers to a test recently made at Indian Head of an armor plate manufactured under what is known as the Chase-Grant process, which according to the Ordnance officials is the application of a chrome face to a steel plate. Armor similar in character was tested last September at the army proving grounds at Sandy Hook, and on the first fire was smashed to pieces. The same results attended the plate tried at Indian Head. It was 5 ft. square and 10 in. in thickness. One shot was fired from a 6-in. gun—an armor piercing projectile weighing 100 lb., having a striking velocity of 2,104 feet a second. The shell was stopped and broken up, but the plate suffered severely from the impact, being cracked to pieces.

formed a corporation, in which were associated the names of eminent men; and yet in connection with armor alone we read that the British Admiralty has concluded that:

"In the course of the experiments the use of nickel as an alloy of steel for the purposes of armor plates has been fully tested. It has been established that Harveyed plates without nickel in the steel show resistance to modern projectiles as great as any hitherto obtained when nickel was combined with steel in plates also treated by the Harvey process. The consequence of adopting this new system will be a great saving in cost for a given defence."

Will Great Britain wait another eighteen years (as she did with the Ellis method of carbonization, now publicly known as the Harvey process) before recognizing the great value of the processes which have reduced the cost of this valuable metal, and by its incorporation increased in so marked a manner the physical qualities of material of which engineers are constantly demanding increased strength and endurance? Slowness of the Admiralty officials.

Will she wait until by the individual efforts of a Fox, or by some other social or personal force, nickel is given in England that position in the metallurgical world that its importance and usefulness demand?[22]

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[22] Captain Sampson, chief of the Bureau of Ordnance of the United States Navy, in a paper read before the Society of Naval Architects and Marine Engineers, makes the following comment on the opinions of the British naval authorities:

"The decision of the Armor Board of 1890 that the Schneider nickel steel plate was softer than that of steel, and allowed greater penetration, was correct for those two plates. Our armor makers however have had no difficulty in making oil tempered nickel steel armor far stronger and more resisting than that of simple steel, while it still retains the characteristic toughness of the nickel. To any metallurgist acquainted with the infinitude of results that may be obtained by a variation in the composition and treatment of simple steel, the advantageous possibilities arising from the introduction of so benign an ingredient as nickel must be apparent. In other words, where simple steel is strong and tough, both qualities may be improved by adding the proper amount of nickel.

"The susceptibility of nickel steel to treatment is remarkable, and yet this steel may be abused in the most shameful way without failure. For this reason the smaller percentage of losses in manufacture will go far toward wiping out the increased cost of machining the tougher material. Nickel appears to render the carbon more sensitive to hardening, and hence water hardened Harvey plates of nickel steel are toughened at depths hardly affected in simple steel plates. Not only that, but the hardening is accomplished with less risk to the plate, and it is for this reason that the manufacturers of the Loire have been able to forego entirely oil tempering armor plates and obtain the increased resistance due to the more severe operation of water hardening. Doubtless the difficulty of spontaneous hardening, which Mr. Ellis mentions as occurring in carbonized nickel steel plates, is due to the sensitiveness of the alloy after its long heat soaking, the plates being removed from the cementing furnace or uncovered in a cold, moist atmosphere while still at a high temperature. It is very rare that any difficulty of this sort occurs in the United States.

"In fact, the only doubt concerning the use of nickel in this country is the feasibility of raising its percentage, now 3.25 per cent., still higher, the improvement and cheapening of the processes of reduction having considerably reduced its cost. In this connection it is well to note that in the Pola, Austria, competitive armor trial of November, 1893, a Witkowitz unhardened plate, said to contain 5 per cent. of nickel, defeated five competitors, including a Vickers Harveyed simple steel plate and a Krupp gas hardened plate. These plates contained between 2 and 3 per cent. of nickel. Finally, in England, where the nickel in Harveyed armor rarely exceeds 2.5 per cent., its peculiar toughening effect is taken advantage of by employing it for unbacked structures, while the Harveyed all steel armor, being more susceptible to racking, is now only fitted on backing. There is therefore nothing in the present application of the Harvey process, nor its future possibilities, to indicate the disuse of nickel in armor; rather that by increasing its percentage the toughness of the foundation plate and its resistance as a whole may be increased.

"The service tests for Harveyed plates for United States naval vessels require them to withstand two shots, the first delivered with the velocity which, according to the Gavre formula, would cause the perforation of a wrought iron plate 10 per cent. greater in thickness, together with 36 inches of oak backing, the requirements being that no crack shall extend from the impact to the edge, or from one edge to another of the plate, and at the

same time through the entire thickness of the plate at an edge. The second shot is at the velocity which according to the De Marre formula would cause the perforation of a Creusot steel plate 15 per cent. greater in thickness, together with 36 inches of oak backing, the requirement in this instance being that the projectile or any fragment thereof shall not pass entirely through the plate and backing.

"These tests are but 15 per cent. more severe than those required for oil tempered nickel steel plates, and are now 3 per cent. less severe than those fixed by the latest contracts in France. It has been claimed that the larger calibers employed in France make the test more severe. This is hardly the case, as in France cracking is not barred. The plate must resist perforation, no part of the backing must be exposed, and the plate must remain in such condition as regards cracks as to enable a second shot to be fired upon it. The velocity of the second shot will be 1.26 as compared with that for ordinary steel as obtained from the De Marre formula, and the blow of this shot shall fall at a point distant 3 to 4 calibers from the first. Should the plate stop this shot a premium of 8 per cent. of the contract price will be paid. Should the plate fail to fill the conditions imposed for the first shot, then another shot will be fired with a velocity of 12 per cent. greater than that capable of piercing an equal thickness of steel, and if the plate successfully resists this attack the lot may be accepted, but at a price reduced 8 per cent. below that agreed to in the contract.

"It would thus seem that the minimum requirement in France after all is hardly as severe as our own; still there are three grades of quality, and three prices under the same contract. It must be remembered however that the tests in the United States do not, as abroad, fix a standard of excellence. They mark the inferior limit, as does the last shot mentioned in the French contract above. The poorest, not the average plate, in an armor-group of 300 to 500 tons must pass this test, or the entire lot is rejected."

SECTION VII.

MINING ACCIDENTS.

The past year has again been marked by a disproportionately large number of accidents, of which an unusually high percentage were of a fatal character. In seven casualties, involving fourteen men, seven men were killed and seven others more or less severely injured. The falling of pieces of rock from the roofs and sides of underground workings is in all countries one of the most prolific sources of accident, and in the mines of our own province last year it was responsible for the death of six out of the seven men killed. Even in the coal mines of England where explosions of fire damp of great magnitude and severity occasionally occur, causing the death of scores and sometimes hundreds of miners, falls of coal and rock far transcend any other single cause of fatal accident, and indeed go far to bring about as many calamities as all other causes combined. Thus, in the eleven years 1875-85, there were 12,315 deaths in the English coal mines from accidents of all kinds, underground and surface, of which 5,021 were due to falls of coal and rock from roofs and sides, while only 2,903 were caused by explosions, notwithstanding the fact that in the latter case there were at least two instances where upwards of two hundred men were killed at one fatality, and six where more than a hundred met their death at one time, while as a rule the deaths caused by falling coal or rock occurred singly, or at most in small numbers at a time. For the twenty-two years 1873-94 the total number of accidents was 23,808, of which 9,992 were due to falls of ground and 4,575 to explosions of fire-damp. Under the closest and most careful inspection, and in the face of what is considered to be ample provision against danger by way of timbering and other means of support, it seems almost inevitable that hidden seams and fissures will lurk in the darkness of the mine ready when least expected to let slip the loosened masses upon the workmen below.

Too high percentage of accidents.

Falls of rock a prolific cause.

It is evident that a valuable aid in the prevention of accidents from this cause would be an efficient system of mine lighting which would disclose cracks and fissures that might otherwise escape unnoticed, and which would also reveal the first symptoms of impending disaster. Where the sole source of light is the candle in a miner's cap, sufficient only to enable him to see the few feet of ground which he is engaged in working, even the keenest vigilance will sometimes fail of ensuring safety. The problem of illuminating underground workings on a large scale, either by a fixed light or temporarily for purposes of making examinations, has not as yet come to the front in this province, for the reason that operations at any considerable depth are few in number. It would offer some difficulties, among which would be the smoke caused by blasting, nearly always present in the atmosphere below ground when workings are continuously carried on; but if the development

Illumination of mines.

of the industry makes the progress which is hoped and looked for, mining companies and proprietors may find it necessary to give this matter their serious attention.

Necessity of constant vigilance.

Under the most favorable circumstances however it is not always easy to detect the lines of fracture present in the roofs and walls of mines, which may be due to the action of frost and water, to movements in the earth's crust, or to explosions of powder within the mine, and their presence may be, and in nearly all cases is, unsuspected until the fatality takes place. Yet it would seem possible by providing good light, by systematic and sufficient timbering, by constant scaling, and above all by incessant watchfulness, to take such precautions as would reduce the danger to life and limb from this cause to a minimum. In a mine eternal vigilance is the price of safety, but the experience of other lands goes to show that while it is not practicable to eliminate the element of danger, it is possible to rob the business of very much of the risk which is attendant upon it where the proper safeguards are either neglected or the necessity for their adoption is not understood.

One source of danger eliminated.

It is satisfactory to note that one cause of accident which figured prominently in the Report of 1893—that of the explosion of powder in heated ore—is altogether absent from the Report of 1894. The steps taken by the Bureau to put an end to the hazardous practice of breaking up hot roasted ore by inserting in it charges of dualin, which had reached a dangerous prevalence in the former year, enforced as they were by enactment of the Legislature, have doubtless been the means of abolishing the custom, and so removing this source of risk from the list of causes of mining accidents in Ontario.

The accompanying table on page 201 gives particulars of the various accidents.

The Ophir Disaster.

Serious fatality at Ophir mine in Galbraith.

The first and most serious fatality of the year was that at the Ophir gold mine in the township of Galbraith on the 5th of March, by which Frank Pacey, James Hoath and Anthony Savage were killed, and Samuel Sanders (or Mudge), David Johns and William Chapman were slightly hurt. A mass of rock became detached from the hanging wall and fell on the heads of the unfortunate miners who were working below it, killing them instantly. A despatch in the Toronto papers gave brief intimation of the occurrence, but no notification having been received from the company as required by the Mines Act, the manager, Mr. J. K. Owen, was communicated with by the Bureau and particulars of the accident requested. On receipt of Mr. Owen's reply the Inspector of Mines, Mr. A. Slaght, was instructed to proceed at once to the scene of the disaster and make a thorough investigation into its causes. Meantime the mine officials had notified Dr. McCort of Thessalon, coroner for the district, of the accident, who visited the mine and after making inquiry decided that it was not necessary to hold an inquest. The Inspector, who was directed to inquire into the advisability of an inquest, also reported that in his opinion one was not imperative. His report, the essential parts of which are given below, went to show that the accident could not have been foreseen, and was therefore unavoidable. In view however of the very

TABLE OF ACCIDENTS IN 1894.

Mining accidents in 1894.

No.	Date.	Company or firm.	Mine.	Name of injured person.	Nature of injuries.	Cause of accident.
1	Jan. 8	H. H. Vivian & Co.	Murray	James Stenton	Burned about the legs	Upset pot of semi-molten metal on icy floor.
2	Mar. 5	Ophir Mining Co	Ophir	Frank Pacey	Killed	Fall of rock from roof of mine.
				James Hoath	Killed	
				Anthony Savage	Killed	
				Samuel Sanders	Slightly injured	
				David Johns	Slightly injured	
				William Chapman	Slightly injured	
3	April 11	Canadian Copper Co.	Copper Cliff	Robert Wightman	Hip bruised	Jammed between car and wall.
4	June 6	H. H. Vivian & Co.	Murray	Thomas Trethewey	Hip dislocated; otherwise bruised	Knocked over high stope by drill shell working loose.
5	Sept. 15	Canadian Copper Co.	Copper Cliff	Thomas Lintley	Killed	Fall of rock.
				Samuel Mattson	Killed	
				John Mitchell	Slightly injured	
6	Nov. 24	Canadian Copper Co.	Copper Cliff	Axel Johnson	Killed	Fell down shaft.
7	Dec. 10	Canadian Copper Co.	Copper Cliff	William Martin	Killed	Precipitated down shaft by fall of rock.

Summary: Killed, 7. Injured, 7. Total, 14.

serious nature of the accident, and of statements which were made to the effect that previous to its occurrence the workmen had demanded that the mine should be timbered, and had in fact threatened to quit work the next Saturday unless this were done, it was deemed proper to order an inquest to be held, and Dr. Scherk of Sault Ste. Marie was accordingly instructed by the Attorney-General's Department to make an official investigation. Mr. J. J. Kehoe, District Crown Attorney, was detailed to assist in the inquiry in order that the facts might be fully brought out. Owing to the unavoidable absence of Mr. Kehoe, it was found impossible to begin the inquest until the 20th of March, fifteen days after the accident. Adjournment was made on that day to 3rd April, when the inquest was concluded. Meantime of course the bodies of the unfortunate men had been buried, but the corpse of Anthony Savage was exhumed, and although the inquest was nominally into the cause of his death only, the investigation covered the cases of all three, their deaths being practically simultaneous and due to the same cause.

n investigation by a coroner ordered.

INSPECTOR SLAGHT'S REPORT.

After setting forth the instructions which he had received from the Bureau, and the preliminary steps of his inquiry, the Inspector goes on to say in his report addressed to the Honorable the Commissioner of Crown Lands ·

Report of the Inspector to the Commissioner of Crown Lands.

On arriving at the mine Friday, March 9th, I was met by the superintendent, who had been advised by the Director of Mines of my coming to investigate the accident, and he stated that whatever assistance could be rendered by the officials would be readily given. On going to the place of the accident I found nothing had been removed or changed other than was necessary to take out the bodies of the victims. A mass of rock (perhaps 10 tons) had fallen from the hanging wall underneath which the men were working at the time of the cleavage. The place where it severed from the wall was about fifteen feet in width at the top, ten feet in height, and in a V shape, the point coming down near the floor. The piece was eighteen inches or two feet in the thickest part, tapering to the edges. It could readily be seen after it had fallen that a seam was between it and the more solid formation from which it had broken. It was a small fold or slab lying against the wall. The overhanging wall has a dip of about 60° at the point where the accident occurred, and an elevation on that incline of about thirty-five feet to the rock roof above. I took measurements of the whole interior workings and made the accompanying tracing to show the condition of the mine as nearly as possible.

Condition of the mine at time of the accident.

The mine had at first been worked from the surface, on which there are three openings. The mineral vein was followed down to a depth of about twenty-five or thirty feet and then worked lengthwise, leaving a rock roof, except at places of surface openings, of say twelve or fifteen feet in thickness. The width between the foot and hanging walls is about sixteen to eighteen feet. No rock pillars were left, nor timbers put in to support the hanging wall, which should have been done and continued as the work progressed. The length of this opening extended about 180 feet, rising nearer the surface along the cutting. At a distance of about 100 feet from the workings above, a perpendicular shaft had been sunk at the base of the hill 100 feet or more in depth, with a view of tapping the vein. Also another incline shaft, following the dip of the vein, had been sunk with a view of intersecting the vertical shaft, but I was informed the connection was not made. These

shafts are closed and filled with water. The more recent workings were begun at a point lower down the hill, say eighteen or twenty feet, on the vein and an adit run in removing the ore between the walls to the upper workings as the work proceeded. A car track is laid on the floor and continues over a trestle tramway into the top of the mill, over which the ore is carried to the mill in small cars. At a distance from the entrance, say thirty feet, a large barren rock or horse was encountered, part of which was left standing as a support to the wall. After passing the barren rock (which was of considerable thickness) the ore had been taken out between the walls aud the working continued to the distance of ninety feet from the entrance to the place of the accident. Part of the ore had also been removed for a distance of fifteen feet farther, where it was intended to leave a pillar to support the hanging wall. The large opening at the surface afforded excellent light for the work below. At the place of accident the distance from the track on the floor to the surface, at the incline of the wall, is forty-eight feet, and about thirty-five feet to the rock roof.

Evidence taken by the Inspector.

When at the mine I took the evidence of all the parties about the works whose statements I considered would be of value in the case, which I herewith submit for your information. Several of the workmen however were absent, having gone to their homes, as work was suspended until all investigations were completed. The coroner, who was early on the ground after the accident, I am informed conferred with all or nearly all the men who had been working in or about the mine recently, before arriving at his conclusion as to the inquest.

Mr. J. K. Owen, superintendent.

Mr. J. K. Owen makes the following statement: I am superintendent of the company's works here, and have had charge of the same since the 15th of November last. I have been associated with the mining industry for about forty years, and part of this time I have had charge in conducting the working of mines, in looking after the men, and in giving instruction as to the manner in which the work was to be done. My experience of this kind of mining work has stretched over a period of at least ten years. I have been of late years more particularly engaged in constructing mills for the treatment of ores. I have built forty of them, and in a large number of cases I have examined the mines connected with them; I have been a consulting party as to how work should be done in them, and in several cases have taken the entire oversight of the work. I also had charge of a gravel pit which required the most difficult timbering to be done. I gave personal supervision to the work in this mine, and began the work on the floor where the tramway is placed. I am in the mine every day, and give instruction to the captain if I think any part of his work requires me to do so. We consult constantly together about the work and the safe condition of the mine. On the morning of the accident, before breakfast, we were consulting about the work. I regarded this mine as in a safe condition, and was overwhelmed with surprise at the occurrence of the rock falling as it did, which unfortunately destroyed the lives of three of the workmen. No person ever spoke to me about the unsafety of the mine, nor have any of the workmen ever left the mine on this account. I was often present in sounding or testing the hanging wall, and where any part appeared unsafe I had it removed. I provided a ladder especially for this work, and not long since in concurrence with the captain had staging erected to remove a small slab of rock which did not appear quite safe.

William Rapsey, captain.

Wm. Rapsey makes the following statement: I am the captain of this mine and have had charge since the 23rd of December last. I have had thirty-two years' experience in mining, and for about fifteen years of this time I have had charge of the underground department of the work as captain, and directing how work should be done. I have had a large experience in timbering up mines and looking after their safe condition. At every shift of

the men in the mine I have the rock tested with a hammer by sounding, and if any part is loose or in any way dangerous I have that part taken down. From the outside appearance of the mine and the constant testing of the walls I regarded it as perfectly safe, and was shocked when the mass of rock fell causing the death of three men. There were six men besides myself at the place of the accident when it occurred, and I had my hand on the shoulder of one who was slightly injured by the disaster. I can account for the cleavage of the rock only on the ground of the sudden change of the weather thawing out the frost, which was severe in this part of the mine, as just above it is the large opening to the surface. The weather had been mild, thawing and raining two or three days before the accident. About one hour before the fall of the rock a single blast was made near by, and if at all loosened by the action of the atmosphere this may have aided in the cleavage. After the rock had fallen it was apparent that it was a part of the fold adhering to the hanging wall. I have carefully tested this part of the wall several times.

John Smith, miner.

John Smith, miner, makes the following statement: I have had about twenty years of experience in mining. I was acting as captain of Arington hematite iron mine, Michigan, for three years. I have been constantly employed on underground work at this mine since the 25th of November last as a miner. I have worked alternately on the weekly day and night shifts. I never heard any of the men working in the mine say that it was in an unsafe state. I have sounded the walls often and often, and regarded it as safe; I would not have worked in it myself if I had thought there was danger. My shift changed on Monday, the day of the accident, and I was not in the mine when the disaster occurred. I have only known of one small piece of rock falling before. This happened some two weeks ago, just after a blast, and it fell before we got to it to trim it down.

Charles Henderson, laborer.

Charles Henderson, laborer, makes the following statement: I had but three months' experience in mining before I came to this mine last fall, and I have been constantly here since. I was not in the mine when the accident occurred on Monday last, when three men were killed by the falling of rock. I have never heard any of the men working here say that the mine was in an unsafe condition, nor have I ever known anyone to leave the mine on this account. When not working in the mine I work on farms as a laborer. Working with experienced miners, I regarded the mine as safe, relying on their judgment. If I had thought it unsafe I would not have worked in it myself.

Joseph Lee, miner.

Joseph Lee, miner, makes the following statement: I have had twenty-two years' experience in mining, and have had charge of tunneling on the Canadian Pacific railway and also at the work on the canal at Sault Ste. Marie. My experience on underground work has been about ten years in duration. I began work here first of February last, and have never heard anyone say the mine was unsafe. I considered the mine quite safe. If I had thought anything was wrong in it I would not have worked in it. I think the falling of the rock may have been caused by the frost. I judge from my own experience in working in King's mountain on the Cincinnati & Great Southern railway in Kentucky, when during the tunneling it would freeze and then thaw, the rocks would frequently be loosened and fall off. This was eighteen years ago this winter.

Dennis Doe.

Dennis Doe makes the following statement: I have had experience in working in mines for four or five years past for part of the time, and part of the time as blacksmith; worked last winter and also this winter on underground work; worked in this mine since November last, but was not in the mine when the accident happened. I always regarded the mine safe, and never heard anyone say it was unsafe. I cannot account for the rock falling unless by action of the frost.

From the evidence taken, which goes to show that the hanging wall was frequently and carefully examined and lately tested at the place of cleavage, as well as from its present appearance, I regard it as by no means certain that special danger could have been foreseen at this point.

The Inspector's conclusions.

That the captain in charge, as well as the superintendent, both of whom have been engaged many years in practical and difficult mining, regarded the mine as safe does not admit of a doubt. Several of the men constantly working in the mine were also old miners, and they foresaw no danger. The place of accident was exposed to clear light, as a large surface opening at a short distance was directly above it, and this gave favorable opportunity to see any defect in the wall if it had been apparent. In view however of this unexpected falling of rock, which unfortunately proved fatal to the lives of three of the workmen, and also as the present working in the mine is beneath the hanging wall which is exposed to changes by action of frost, I regarded it as necessary to give written specific instructions to have substantial timbers placed as supports under the rock roof, and against the hanging wall, with lagging over the tramway in every part where any falling of rock might occur before any further work was done on the floor of the mine. I also directed that substantial ore or rock pillars be left at suitable distances for supports to the hanging wall as the work proceeds.

The Inspector cannot compel witnesses to give evidence, nor can he take their testimony under oath, and in this case a considerable number of the men who had been working in and about the mine had gone to their homes and were not accessible. It may also be stated that the depth of snow on the hill prevented a very close examination of the formation of rock from the surface. My examination was therefore of necessity somewhat limited, and it was considered under the circumstances that a coroner's inquest would be more satisfactory to determine whether the sad accident was the result of incompetency or carelessness on the part of the management in the mine.[1]

The information given by the witnesses at the inquest did not bear out the statement that the miners had threatened to abandon work unless the mine were timbered, but it brought out the fact that small pieces of rock had been noticed dropping from the roof shortly before the main body fell. One witness had observed three separate pieces falling during the forenoon, the accident taking place at a quarter past eleven o'clock. It is easy to characterize as recklessness the disregard which the men showed of these warnings, but as the light was good they probably thought—if they thought about the matter at all—that if any seam existed in the roof it would be visible, and consequently paid no attention to the small falls of rock. None of the miners who were examined, including Sanders, Johns and Chapman, who narrowly escaped the death that overtook the other three, regarded the mine as dangerous, notwithstanding the want of timbering. One old miner residing in Bruce Mines, named John Nicholas, who had had twenty-seven years' experience in Canadian, Michigan and Colorada mines, had visited the Ophir in February, 1894, the month previous to the accident, and swore that from the appearance of the mine he then formed the opinion that for the protection of the employés it required to be timbered. It is difficult to resist the conclusion that had extraordinary regard been had by the management for the safety of the workmen a system of timbering would have been introduced.

Premonitory symptoms of the disaster.

[1]By section 8 of the amending Act of 1894 (cap. 16, 57 Vic.) section 67 of The Mines Act 1892 is amended by adding the words: "And in conducting an enquiry into the cause of loss of life or of personal injury to any person in or about a mine, the Inspector shall have power to take evidence upon oath."

But it is easy to be wise after the event, and in the opinion of the coroner's jury, of which Mr. R. E. Miller was foreman, the occurrence was an accidental one, for which the mining company was not responsible. Their verdict was "that the deceased Anthony Savage came to his death by the falling of the rock on him at the Ophir mine, and that the said cause of death was purely accidental, and that no blame is attached to anyone therefor."[2]

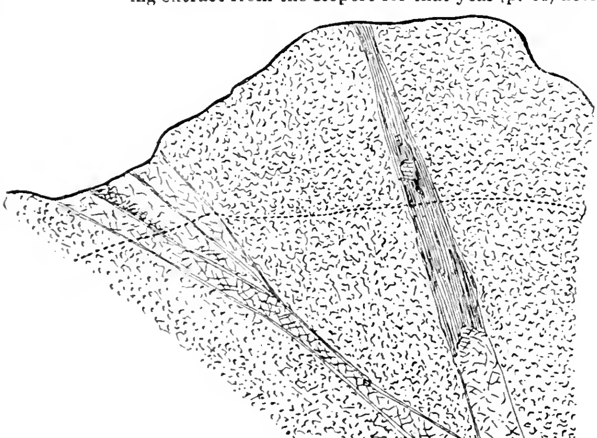
Verdict of coroner's jury.

THE FATALITY AT COPPER CLIFF.

The Copper Cliff accident.

An accident similar in character, resulting in the death of two men and the injury of a third, occurred at the Copper Cliff mine of the Canadian Copper Company on 15th September. The men killed were Thomas Lintley, a Finlander, a young married man who left a wife and two small children, and Samuel Mattson, also a young married man, but without children, whose wife was living in the old country. The injuries of John Mitchell, who was also involved in the accident, were slight, and he was able to resume work in a few days. The gravity of the occurrence called for a special investigation by Inspector Slaght, who was accordingly instructed to proceed to the mine and make a report after full inquiry. The Copper Cliff is the deepest of the copper-nickel or in fact any of the mines now being worked in the province, and its underground operations are on an extensive scale. Every facility was afforded the Inspector by the management of the mine for making a thorough investigation. After examining the scene of the fatality and collecting all the evidence possible as to the cause of the accident and the condition of the mine at the time of its occurrence, the Inspector made the following report prefaced by the statements of witnesses of the accident and workmen who were familiar with the state of the workings underground :

[2]The Ophir mine was inspected by the Director of the Bureau in 1893, and the following extract from the Report for that year (p. 44) deserves to be reproduced in connection with the account of this accident: "My first visit to the Ophir mine was made early in the month of September, when the mill was in course of construction. I returned again in October, a week after the works had started. I found all parts of the mill to be in a safe condition, as required by the Mining Regulations. The mine was also safe at that time ; for although stoping work had been carried on to some extent in each of the adits, the roof was well supported by pillars and masses of ore. It was pointed out to the superintendent however that as the roof was evidently cut off from the country rock behind it by the fissure vein, so that it hung like a V-shaped body over the worked-out portion of the mine, it would be necessary to put in ample timber supports before the ore bodies between the several adits were stoped out. In this view the superintendent fully concurred ; but his connection with the mine ceased at the end of October." It was this experience of failure to carry out instructions due to the possible change of mine managers, it may be remarked here, which led to the adoption of the regulation for a permanent register of the Inspector's instructions. See p. 214.



REPORT OF THE INSPECTOR.

Report and statement of examination relating to an accident in the Copper Cliff mine, which occurred on Saturday the 15th day of September, 1894, when a rock falling from the roof of the seventh level of the mine and tilting over after landing killed two men and slightly injured a third, named respectively Thomas Lintley, Samuel Mattson and John Mitchell. The Inspector's special report on the accident.

Charles Jackson, laborer, sworn: I have been mining four years, and for fourteen months at this mine. I have done almost every kind of work in the mine, and especially running a drill and scaling walls. Where we were working we scaled off every loose part and left the wall good and solid. I have scaled all over the sixth and seventh levels overhead, and other places needing scaling. I have gone over twice these parts of the mine within two months past. I had not heard anyone say that the mine was in any way dangerous before the accident, and have never known anyone leave the mine because it was unsafe. I have regarded it as safe myself, but since the falling of the roof I regard that special place as requiring careful looking after by way of testing it. Ladders sufficient are always kept in the mine. Charles Jackson, laborer.

Charles Gribble, miner, sworn: I have been mining 12 years, and since January at this mine. I have been running a drill; also scaling for my own security and that of my partner. It was a usual practice to scale our own ground. I have not been working for three weeks past because of an accident to one of my fingers. I have heard no parties complain of danger in the mine before the accident. One piece of rock fell long ago. I am not afraid to work in the mine. I regard it safe. Ladders always were in the mine for use in scaling. Charles Gribble, miner.

John Mackey, miner, sworn: I have been mining three years, three weeks here. I work in the sixth level. I regarded the mine as safe before the accident. I scaled my own ground. John Mackey, miner.

Fred Dishane, miner, sworn: I have been mining six years and since 1st of May at this mine. I never worked in the seventh level. We scaled our own ground. I always regarded the mine as safe and was not afraid to work in it. A rock fell a few months ago in the sixth level and slightly injured a man. I never knew of any rock falling in the seventh level before the accident an 15th inst. I never heard parties complain of the safety of the mine before the accident. Fred Dishane, miner.

Joseph Keen, miner, sworn: I have been mining two years and a half, and at the Copper Cliff one year and three months working on a drill, also mucking and trimming the walls of the mine and the roof. We did the scaling as we went along with the drill work. I never knew of any rock falling. One 40-foot ladder and some shorter ones were kept in the mine for scaling. I helped scale up near to the winze about as far as where the rock fell off. Some small stones fell on the sixth level, but not to amount to anything. I considered the mine safe. Joseph Keen, miner.

Daniel Wink, miner, sworn: I have been mining about twenty-eight years, and seven years at the Copper Cliff and Evans mines. I am shift boss and have acted as such during my connection with the company for some two years at different times. I have worked on the seventh level, and always considered it safe. I scaled the sides and roof as our work went on, but did not scale about the part where the rock fell. I never considered that part dangerous, and I know men were scaling there before. That part was scaled two or three months ago. I never heard any parties say the mine was unsafe, and I always considered it safe myself. I never knew of rock falling in the seventh level. In the sixth some small pieces fell, and then when any of the rock seemed loose it was at once taken down. Ladders and ropes are Daniel Wink, miner.

provided in the mine for this purpose. Scaling is done after every blasting, and a shift of from four to six men go down after midnight on Sunday to look over all loose ground and remove any rock likely to fall. This time is chosen as all smoke is out of the mine and the walls can be clearly seen. This course has been constantly carried on during my term for the past two months as shift boss. Every part of the mine is examined where work is going on and made safe.

Herman Baultz, miner.

Herman Baultz, sworn: I am a miner and have been most of the time engaged for the past eight years mining, and for seven years at Copper Cliff. I have worked at all kinds of work to be done in the mine. I have done a considerable part of the scaling and was engaged for two months at one time steady at it. I have worked constantly in the seventh level since work began this last time, on the 7th of August. I have been working at sinking the shaft. During the latter part of May and June and the early part of July I scaled over the entire roof of the seventh level with three other men, and every part was left solid. I did not see anything defective in the region of the winze, where the rock recently fell causing the accident. We had ladders—two long ones and three short ones—and when one was broken another was supplied. We also had chains and ropes to use for scaling. The seventh level I regarded as all right. I never heard anyone complain that this part of the mine was unsafe, and the men helping me do the scaling said it was all right. I could not say why the rock fell, but think there must have been a slip.

Henry Davis, mining captain.

Henry Davis, sworn: I have been captain of the Copper Cliff, the Evans and Stobie mines for about one year. I have been engaged in mining for over forty years, and have had charge of mines for thirty years, including the copper mine known as the Evergreen Bluff mine, Michigan on lake Superior I had charge of this mine for eight years; also the Jackson iron mine, Marquette county, Michigan, for one and half years; also the Smith iron mine, Michigan, for two years, and the Metropolis iron mine a short time; also the Goodrich mine, Michigan, for eight years and the Ludington mine in the same state for four years. I regard the timbering of the class of mines such as these under my charge as impracticable except in shafts to render them secure, and for the purpose of skips, track ways, and pentice work. I was absent on a visit to my family in Michigan when the accident occurred, and was greatly surprised to receive the news, as I regarded that part of the mine where the rock fell as perfectly safe. I examined the place whence the rock had fallen on Tuesday, on my return, and could readily understand the cause, as slippery seams appeared behind it, and it is probable the concussion by blasting in the mine had loosened it. The piece was an inverted V shape, and would be perhaps a couple of tons in weight. The falling rock on striking the ground tilted over on the two unfortunate men killed. I have given close attention to this as well as every other part of the mine by having the roof and side wall scaled off as the work proceeded, and in addition sent a shift of from four to six men every week after midnight on Sunday to trim the walls and to look the whole of the work carefully over. I selected this time for scaling as the smoke during the Sabbath had entirely vanished from the mine, and the defects could more readily be discovered. In every instance of blasting, the rock is carefully examined and the loose pieces removed. The part of the mine where the accident occurred had been scaled at a not distant date, and was then regarded as all right. It is by no means certain that the defect could have been detected before the cleavage. My long experience in managing mines convinces me that accidents will sometimes occur when and where least expected, and I regard this as one of them, as all reasonable care had been taken for the safety of the workmen.

John Mitchell, sworn : I am underground foreman in the Copper Cliff mine, and have charge of all the work underground. I have had trimmed down all the rock from the roof of the seventh level that needed to come down, and always did the trimming of the walls after midnight on Sunday. It was a convenient time to do this work for the men, and also because the mine was free from smoke. It was something over a week before that the place where the rock fell off was trimmed. That place was regarded as entirely safe, as the ground there had been tried and was supposed to be solid, and I did not go to it. Since I have been in the mine I regarded the seventh level as the best part to work in, and never heard anyone say that it was unsafe. If I had considered it at all unsafe I would not have worked there myself. I never knew of anyone leaving the mine because it was unsafe. Any amount of appliances are at hand to do scaling. Generally I have two to four men with me in scaling at the special time stated, but scaling was done right along as the work progressed daily. Jno. Mitchell, underground foreman.

The Inspector then states the result of his own observations and his conclusions as follows :

The seventh level was the scene of the fatality. The stope in this level is 40 by 90 feet at the floor, and has a raise of 38 feet to the rock roof above, which is 12 feet thick at the winze and increases in thickness as it goes back. The opening is of arch shape, narrowing from near the floor to the roof. At one side a large ore pillar is left as a support to the roof. The formation was firm, and from outward appearances there was no danger of portions becoming detached, and I ascertained that the walls and roof of this level had been recently examined prior to the accident and all loose rock trimmed off. Care was taken to have the whole surface of the walls and roof examined weekly, and when work was being done after each blast scaling immediately followed. The accident occurred near a point where the winze is cut through between the sixth and seventh levels. The size of the fallen mass would average four by five feet by about eighteen inches thick, and would weigh about two tons. The distance from the floor of the level to the roof as before stated would give a fall of 38 feet. I examined the place from which the rock had fallen and found there had been a hidden seam behind it. The detached piece resembled somewhat an inverted V in shape, and was in all probability loosened by the concussion caused by blasting. On the morning of the 15th inst. a blast had been put off in the sixth level, and shortly afterwards the accident happened. I had the rock in the immediate vicinity of the cleavage examined with the aid of a lighted lamp, and tested with the hammer. The test showed it to be firmly placed. The captain I regard as a competent man, and with his large and varied experience, his systematic method of working, and his close attention to the work in the mine by his daily visits to the places of working, there can be but little doubt that all ordinary precautions were taken and reasonable efforts made to prevent accidents. In this particular instance it is barely possible that a more recent examination of the place from which the rock fell might have detected a loosening. However, upon my closer inspection of both the place of cleavage and the rock itself, I am of the opinion that the break was new. I had a sample of rock broken off, and a comparison of it with the side of the fallen mass which had been next the seam strengthened my conviction that the loosening had been simultaneous with the fall. Human life is precious, and a disaster such as the present one is greatly to be deplored, but after a thorough examination of the place of accident, and taking the sworn depositions of numerous witnesses employed in and about the mine, I am satisfied that the operation of the mine was carried on with all due precaution for the protection of the workmen and that no blame can attach to the men in charge. The Inspector's opinion as to the cause of the accident.

A coroner's inquest in the matter.

An inquest on the body of Thomas Lintley was held by Dr. McMurchy of North Bay, coroner, and the following verdict was returned by the jury: "According to the evidence given in the accident causing the death of Thomas Lintley on September 15th, 1894, the verdict of the jury is that the accident could not be foreseen, and that the Canadian Copper Company be exonerated from all blame."

Axel Johnson's Death.

Axel Johnson's death at Copper Cliff mine.

The case of Axel Johnson, who was killed at the Copper Cliff mine on 24th November, is next on the list. Johnson is described as a sober, steady young man, thirty years of age, and a Swede by birth. The circumstances under which he met his death were set forth by the Canadian Copper Company in reporting the accident to the Bureau as follows:

The man Axel Johnson, who was killed in our Copper Cliff mine on the 24th ult., was employed as a pump man. We are sinking our shaft from the seventh to the eighth level, and have on the seventh level an engine for hoisting the rock which is blasted out of the new shaft. He was signalled by the man in the shaft to come down to attend to some water pipes requiring his attention. He was standing by the shaft at the seventh level at the time the bucket had started to go down. It is uncertain whether he took hold of the rope to which the bucket was attached, or whether he jumped for the bucket and missed it. Unfortunately he did not signal the engineer, who was within a few feet of him, to stop the engine.

The consequence was that he fell to the bottom of the shaft, and when taken up was lifeless, his neck having been broken by the fall. Dr. McMurchy of North Bay was notified of the death, but did not deem it necessary to hold an inquest, it being evident that the accident was due to the carelessness of the man himself.

William Martin's Fatal Fall.

Death of William Martin at Copper Cliff mine.

The remaining case of accident resulting in death is that of William Martin, who on 10th December was precipitated down the same shaft in the Copper Cliff mine as that in which Axel Johnson was killed two weeks before. Deceased, with five other men was engaged in preparing this recently sunk shaft for the reception of timbers to form the division between the skip and ladder ways. For this purpose they were, mounted on a scaffold made of green pole stringers, with ends pocketed in notches cut in the hanging wall, the other ends being driven wedge-shape against the foot wall. On these stringers was stretched a flooring of new pine plank. The recesses being cut in the walls for the insertion of timbers, were about breast high, or five feet above the platform. On the day of the casualty the men had completed about seventy-five feet up from the bottom of the shaft, and were engaged in cut. ting out notches for the reception of other timbers, when without warning a piece of rock 1 by 2 by 2 feet in size fell from the hanging wall about five feet above the platform, and breaking the plank on which Martin stood, caused him to drop through the hole thus made down the shaft and into eight feet of water at the bottom. He was taken out as quickly as possible, but

died of his injuries at one o'clock of the 12th December. By direction of the Attorney-General's Department an inquest was held on his body by coroner McMurchy of North Bay, on the 13th. The following evidence was submitted, which clearly sets forth the circumstances under which the accident occurred : Inquest by Dr. McMurchy.

THE CORONER'S INQUEST.

Murdoch Henderson : I was working on the scaffold at the time. I went up to the seventh level for some tools They shouted 'fire' in the sixth level, and I called down to the men that they were firing in the sixth level and that they had better come up. The captain and Mr. Hambly came up, and the working men stayed down. I remained in the seventh level until the firing was over. I went down then. I passed under Paul Baultz, where he was working on the ladder. I went towards the hanging wall beside my partner, Herman Baultz I was standing under the shelter of the wall. Martin was on one end of the plank and Herman Baultz and I were standing near by, on the same plank. Martin said, 'I am afraid three of us are too many on this one plank.' I tried the plank by springing on it, and I moved off towards the foot wall. I thought the plank was strong enough to support three. Sometimes a piece of rock falls off suddenly without warning. I saw the rock fall : it fell about five minutes after the firing on the sixth level. The levels are numbered from top to bottom. I think the rock fell through the effects of hammering on the wall, at the end of the piece that fell. I noticed the rock separating. I said to the man who was pounding to look out, that the slip was opening up. We did not think that there was any large piece loose. Martin was standing on the plank, over the pole supporting the stage. He stepped back when I spoke. The rock was two feet square and 12 or 14 inches thick. I am satisfied that the company take every precaution for the safety of the men. Mr. Hambly looks after the mine, to see that it is in a safe condition for the men to work. Martin did not step off the plank. It is customary for the men to come up off the scaffold during the time of firing. If they do not come up they are taking a risk which the company does not ask them to take. The company raise no objections to their coming off. Murdoch Henderson.

Paul Baultz : I was in the mine when William Martin was injured. I was working with deceased. We were timbering the shaft. I was about four feet higher up the shaft than deceased. I did not see deceased fall. I heard rapping on the pipe, and think some rock fell at the time. Deceased was a careful man, and I do not think that the accident was due to any carelessness on his part. I did not observe any loose rock. I do not know what he was standing on when he fell, I saw the light falling. The foreman went down to pick him up. He (the foreman) was about 30 feet away at the time. The scaffold was safe to work on. The rock in falling broke one plank of the scaffold. The rock fell about four feet before striking the scaffold. The scaffold was of two inch plank and about 15 or 16 feet in length. Only one plank was broken—a plank ten inches wide. Paul Baultz.

Henry Davis, mining captain : It was about 70 or 75 feet from the bottom of the shaft where the men were working. During the two weeks that the men were working there was a possibility of this rock falling. The Government Inspector examined the shaft. I have been down the shaft scores of times and did not notice that rock. I was down every day for the last week. It is my business to examine the shaft and the progress of the work and the mine generally. If I find anything defective I report it and have it looked after. I do not think that the men were careless. I am satisfied that it was through the rock falling that the accident occurred. There were six men Henry Davis, captain.

on the scaffold at the time. The Government Inspector visits the mines about three or four times a year. His last inspection was made in August. He has visited the mines three times during the last fifteen months. It is understood that the men are at liberty to leave their work when blasting is being done, as soon as the signal is given. I made a personal inspection of the wall at the spot where the rock fell and did not see any crack.

James McArthur, manager.

James McArthur, general manager: The work going on at Copper Cliff at present is simply development work for the purpose of putting the mine in a safe state. There has been no ore hoisting since the 15th November, and this new shaft where the accident occurred is simply in process of construction and putting the mine into a safe state for resuming work. I might say that our present work is simply a series of inspections and scalings. Before resuming work again on any of these mines I have to notify the Ontario Bureau of Mines and Mining Inspector, and we have to do the same thing on the closing down of a mine. I presume that this notification is to give the Inspector an opportunity to visit the mines before resuming operations. The blasting in the sixth level was development work. This development work we expect to go on all winter. The Government Inspector was here in May, and spent three or four days inspecting the mine.

Thomas Hambly, foreman.

Thomas Hambly: I was foreman when the accident occurred. Part of the men were working at timbering. Timbering the shaft is putting it in condition for operating the skip. The skip is the bucket. The shaft is divided into three compartments. The first is a ladder road; the other two are skip roads At the time of the accident the men were getting ready to put in the dividing pieces. There was about seventy feet of the shaft divided. The scaffold on which the men were working was independent of the dividing timbers. At the time of the accident I was up in the drift. The scaffold was safe, and did not give way. Only one plank was broken. The plank was broken by a rock falling on it. The size of the rock was about two feet square and about one foot thick. I was not aware of any loose rock likely to cause an accident. The rock did not fall from the place where Baultz was working. Paul Baultz was working six or seven feet above the scaffold, on the ladder road, and the rock fell from about three feet below him and about three feet nearer the centre of the shaft. Wm. Martin fell about seventy or eighty feet. There was about seven or eight feet of water at the bottom of the shaft. The men were timbering and scaling at the same time. I helped to take Martin out of the water. He was unconscious at the time. We were working on the job about two weeks, night and day, there being about six or seven men on each shift.

Herman Baultz.

Herman Baultz: I was working on the scaffold when the accident happened. I did not see Martin fall, or the plank break. I had one foot partly on that plank, but was looking up and did not see the rock fall. I did not notice that that rock was loose. The foreman was in the seventh level, having left the platform a few minutes before. I think the wall was examined by the foreman or Captain Davis.

John Doney.

John Doney: I was working on the scaffold at the time of the accident. I did not think the wall was unsafe. I did not see the rock fall, as I was working with my back towards the other men. I was about the centre of the shaft, at the foot wall.

Dr. Arthur.

R. H. Arthur, M.D.: On Monday morning, the 10th inst., I was told that there was an accident in the mine. I arrived here in time to see them bring the injured man, William Martin, up from the mine. He was injured about the anterior half of the scalp. Two ribs were broken on the right side. He was never conscious from the time of the accident until his death. I examined the wounds carefully, and found no fracture of the skull, no

external wound sufficient to cause death. He died about one o'clock a.m. on the 12th inst. The immediate cause of death was injury to the brain.

The jury found the following verdict: "That the deceased came to his death through injuries received through rock falling accidentally while in discharge of his duties on the 10th day of December, 1894, and that we find no blame is attached to the company or any of its employés. We feel that there is not a proper inspection of these mines by the Government Inspector." Verdict of the jury.

That the jury were right in finding the cause of death to be accidental and unavoidable seems to admit of little doubt, but a perusal of the evidence will fail to show what ground they had for censuring the Inspector of Mines, or what relevancy there was in adding a rider of such a character to their verdict. The jury's peculiar conclusions. The nature of the inspections by that officer of the mines of the Sudbury district was not in question at all, nor was any testimony adduced showing how carefully or how frequently these inspections were made, except in the case of the Copper Cliff. Yet the jury assumed, in the almost entire absence of evidence on the point, to say that there was not a "proper inspection of these mines" by the Inspector. It is by performances of this kind that the findings of juries are brought into disrepute. If the jury meant anything at all by this part of their verdict, they meant that a more frequent and thorough inspection of the mine might perhaps have warded off this unfortunate accident. However valuable a competent inspection may be, it is not pretended that it can ensure absolute immunity from mishap, and in this case it was stated in the evidence of Henry Davis, the mining captain, that he had been down the shaft scores of times, including every day for the week previous to the occurrence, yet without noticing the piece of rock which subsequently fell, notwithstanding that it was part of his business to examine the shaft and report anything he found to be defective. He added that he had made a personal inspection of the spot where the rock fell and did not see any crack. In face of this constant and minute examination, which in such a case must be more efficacious than the most thorough examination that any official can make, it can hardly be pretended that another visit or two in the year would have saved the life of William Martin. Indeed, the office of a mining inspector is not so much to look for tiny seams, weak planks, or loose pieces of rock, as to see that work is carried on upon a proper system, and that the prevailing conditions respecting ventilation, support of roofs and walls, shafts and ladder-ways, etc., are such as to conduce as much as possible to the health and safety of the workmen. It is the bounden duty of an inspector to call attention to any defect, however small, which may in his opinion be a source of danger to life or limb, but it is manifestly unfair to hold him responsible for an accident which does not seem to have been due to any lack of proper appliances, or to an unsafe method of working, and which the careful watchfulness exercised by the miners themselves failed to foresee or prevent. In the case of the Copper Cliff mine where this accident occurred it was shown by the evidence of Captain Davis that the Inspector had visited it three or four times during the year, and by the evidence of Mr. McArthur, the general manager, that at the time of the accident the mine was closed down for the year, and that the only work done was simply development work for the purpose of putting it in a safe

state. The Inspector's own report shows that he visited the mine three times, in the months of March, August and September. In view of all these facts the attempt of the coroner's jury to censure the Inspector seems to be inexplicable from any intelligent or reasonable point of view.

Other cases of accident.

The other cases of accident, which were non-fatal in their character, do not call for special mention. The most serious was that of Thomas Trethewey, who on 6th June was working a drill on a high stope in the Murray mine, when the shell of the machine worked loose and came off, knocking him over the stope. His hip was dislocated and he sustained several bad bruises and contusions. On 15th June he was reported as making good progress towards recovery.

The Inspector's Book.

New mining regulations.

With the object of rendering the work of mining inspection and the recording of information more systematic and permanent, and at the same time of affording miners and employés an opportunity of learning the Inspector's opinion of the condition of any mine or works after a visit of inspection, an Order in Council was passed on the 23rd June, 1894, at the instance of the Bureau, under section 6 of The Mines Act 1892. The order reads as follows:

1. The Inspector of Mines shall present to the superintendent, manager or mining captain of each and every working mine and mining works a book to be called the Inspector's Book, in which he shall record his visits to the mine and works, duly dated and signed, and shall set forth upon each visit thereto made by him:

(1) Extent of mining operations as shown by the number and measurement of shafts, winzes, drifts, adits, stopes, pits and open works;

(2) Machinery employed in or about the mine for drilling, hoisting, breaking, etc.;

(3) Plant for roasting, treating, milling, smelting and refining ores or metals;

(4) Condition of the mine, machinery and plant in relation to the health and safety of miners and all other employes; and

(5) Any instruction or direction authorized by The Mines Act 1892, or amending Acts, deemed necessary to further secure the health and safety of miners and other employes engaged at the mines and works.

2. The Inspector's Book shall be kept in the office of the superintendent, manager or mining captain at the mines and works, and shall be accessible to the miners and all other employes during office hours.

3. A printed copy of these regulations shall be affixed to the outside cover of the Inspector's Book, and as many copies as may be necessary shall be posted by the inspector in or about the mine and works for the information of miners and all other employes.

What it is hoped they will accomplish.

It is believed that the access which will thus be afforded miners and workmen to all memoranda made by the Inspector as to the condition of a mine or works, and to all directions which he may deem necessary to give for the better protection of the health and safety of employes, will be of material assistance in the maintenance of good working conditions. If the Inspector

find anything which requires to be remedied, the employés will be put on their guard against the possible source of danger; if, on the other hand, he find everything in good order, they will perhaps be able to go about their work with a greater feeling of confidence and security. And in the event of a change in the management of a mine or mining works taking place before the Inspector's instructions can be carried out, the book will inform the succeeding manager what the condition of the mine or works calls for at his hands. In any case, the condition of a mine or other works being an all-important matter to those employed therein, it is but right that means should be provided to make them acquainted with the conclusions arrived at on the subject by the officer appointed for the purpose by the Government.

T. W. G.

SECTION VIII.

SUMMER MINING SCHOOLS.

Technical instruction.

The subject of technical instruction in its various relations to the mining industry was discussed in the Report of the Commission on the Mineral Resources of Ontario, and especially in relation to the interests of prospectors and miners, mining engineers and metallurgists.[1] In their Report (p. xxiii) the Commissioners say :

Practical and and scientific instruction in mining and metallurgy.

"In order that the mineral resources of the province may be successfully and economically developed it is desirable that measures should be taken for the practical and scientific training of all who may engage in the industry. Prospectors and explorers are found to be very deficient in the kind of information which would enable them to prosecute their arduous labors to the best advantage; and your Commissioners recommend for that purpose the adoption of a scheme such as has been tried with gratifying results in the colony of New Zealand, and fully explained in Appendix L. But for the education of mining engineers and metallurgists a thorough system of instruction is called for, which can only be provided by establishing a School of Mines or enlarging the course of studies at the School of Practical Science in connection with the Provincial University. It is the opinion of your Commissioners that if the duty of providing instruction of this character devolves upon the Government the obvious plan is to take advantage of the means which are available in the University courses of study, and to make such additions of instructors and appliances as may be necessary for a thorough equipment."

The School of Practical Science.

The second suggestion in the foregoing extract was quickly taken up by the Minister of Education, and a mining department is being developed in the School of Practical Science as fast as the circumstances of the country appear to call for, although not as fast as those most specially interested would desire. Additions to the staff and equipment of the School are made at frequent intervals, and before the close of the present year it will be in a position to satisfy the most urgent wants of mining men. The first suggestion however was allowed to linger in abeyance until a year ago, when an experiment upon a small scale made by the Kingston School of Mining showed not its utility merely—for that had been fully demonstrated in New Zealand—but that there was a demand for it, and that miners and prospectors would readily avail themselves of the advantages of a course of practical instruction whenever the means for it were provided. Accordingly, in the session of the Legislature in 1894, an appropriation of $2,000 was voted for

Summer Mining Schools.

[1]See Report of the Commission, p xxiii, pp. 415-20, and pp. 513-21. The first of these references contains the recommendation by the Commissioners of the scheme adopted in New Zealand for giving practical instruction to miners; the second deals more generally with technical instruction, but emphasizes the utility of the New Zealand plan ; and the third (in Appendix L of the Report) summarizes the plan from the official Reports of the New Zealand Government.

the purpose of organizing Summer Mining Schools in the northern districts of the province, and the inception of the work was entrusted to the Faculty of the School of Practical Science. The following Report shows how the work of the first year has been carried out, and how the project has been received by the men whom it chiefly concerns.

REPORT OF THE INSTRUCTORS.

School of Practical Science,
Toronto, Dec. 15, 1894.

Letter of transmission.

Dear Sir,—In accordance with instructions received from the Minister of Education, I have forwarded to you the Report of the instructors of the Summer Mining Schools for the past summer. Yours truly,

LOUIS B. STEWART, Sec'y.

A. BLUE, ESQ.,
Director Bureau of Mines.

To the Council of the School of Practical Science, Toronto:

Sirs,—We herewith have the honor to submit to you our report on the Summer Mining Schools, established by the School of Science and conducted by us during the summer of 1894.

Organization at Sudbury and Copper Cliff.

In pursuance of instructions received from the Principal to proceed to Sudbury and there to conduct Summer Schools for miners and prospectors, we left Toronto on Monday, July 1st, having previously made the necessary arrangements as to equipment, etc.

On our arrival at Sudbury we spent some time in making the acquaintance of those interested, in explaining the nature of the work and in visiting the various mines in order that all might be notified in time to take advantage of the opportunity. Those mines which we were unable to personally visit were communicated with by mail.

It was finally decided to hold classes both at Copper Cliff and Sudbury, as this arrangement was found to be most convenient for all concerned.

In Sudbury the use of the public schoolhouse was obtained through the courtesy of the school board, and it proved eminently suitable for the purpose. At Copper Cliff we were granted the use of the band-room, which, although not as suitable as could be desired, answered the purpose fairly.

The classes were held in Sudbury on Mondays, Wednesdays and Fridays at 7 p.m.; and at Copper Cliff, as the men are divided into day and night shifts, it was found necessary to hold classes in the afternoon at 3 o'clock and in the evening at 7 o'clock on Tuesdays, Thursdays and Saturdays, thus giving both shifts an opportunity of attending.

The classes were opened on Monday, July 9th, and were continued regularly until August 15th.

Organization at Rat Portage.

While at Sudbury we received instructions from the Principal to proceed to Rat Portage and there to continue the classes.

In compliance with these instructions we left Sudbury on August 16th and opened the class at Rat Portage on Monday, August 20th. At Rat Portage we were materially assisted by the committee previously formed there in connection with this work. We were offered the use of the schoolhouse in which to conduct our classes, but owing to the fact that the school was about to reopen it was found advisable to engage a hall for our purpose.

The classes here were held on Tuesdays, Wednesdays, Thursdays and Fridays at 7 p.m., as a large proportion of the men found it impossible to attend more frequently. Afternoon classes were established later on for the benefit of those who were unable to attend at the beginning.

The work was discontinued on Friday, September 21st, and we arrived in Toronto on Tuesday, September 25th.

Lectures on

The use of text books was not advocated until the classes had obtained a fair idea of the subjects taken up, and then certain works were recommended for those who desired to further advance themselves in the work. The classes were advised however to make careful notes on the practical work and lectures. For the purpose of illustration where blackboards were not available, large sheets of blank paper and colored chalks were employed, and served admirably for the purpose. The course of instruction was made to embrace the following subjects :

Subjects of the course.

Geology, including mining geology and ore deposits.
Mineralogy, including practical work with the blowpipe for the identification of minerals.
Lithology, with special reference to the rocks of the region.

It was intended in the beginning to deliver lectures on elementary chemistry and to illustrate them with experiments ; but for want of time these lectures were abandoned. Some instruction however in elementary chemistry bearing directly on mineralogy, geology and blowpipe reactions were given during the course.

The practical work and instruction in the subjects taken up was made to bear more or less directly on the region where the class was held, thus adding a special local interest.

Cost of the course to students limited to the blowpipe outfit.

No fee was exacted for instruction, but a small sum ($2.50) was charged for a blowpipe outfit which became the property of the student. This arrangement was found necessary, as the practical work could not be carried on without these appliances and as it was impossible for the men to obtain them in time. These blowpipe kits were designed especially for the work, and contained everything necessary for the ordinary blowpipe operations. The expense of these outfits was covered by the amount charged for them.

At Rat Portage the number of kits was found to be insufficient, and some additional appliances were ordered for those not already supplied, one dollar being charged for the use of these.

A collection of typical rocks and minerals was taken for the purpose of illustration ; also a supply of the various reagents required for blowpipe work.

Manner of treating the subjects of the course.

The time was so divided that about one-half of each meeting was devoted to practical work and the other half to lectures. The subjects previously mentioned were treated in the following manner :

Geology.—(*a*) Historical Geology. An account was given of the origin of the earth and a synopsis of the formation of the primary rocks, reference being made to their economic importance and local development. This was followed by a description of the stratified deposits, and their geological sequence explained and graphically represented.

(*b*) Dynamical and Chemical Geology. The different rock and mineral forming agencies were briefly considered ; the growth and subsequent alteration in the various rock deposits were noted, especial attention being directed to such phenomena as are of importance to miners and prospectors.

Lithology.—The various classes of rocks were considered regarding their appearance in the field, their economic importance and other points. Volcanic and metamorphic effects on the local rocks were especially mentioned. Hand specimens of the various rocks were exhibited and some microscopic sections also shown.

Local Geology.—Under this head special instruction of local importance was given.

Mining Geology.—This subject was thoroughly expanded owing to its great economic value. The nature, mode of occurrence, value, etc., of the various minerals and gangues were thoroughly explained. In Sudbury especial attention was directed to nickel deposits, and at Rat Portage to the nature and occurrence of auriferous matter. Methods of estimating the value of mineral deposits and of reporting on mineral lands were thoroughly explained.

Mineralogy.—The lectures on mineralogy were made to bear directly on the economic minerals occurring or likely to occur in Canada and the province of Ontario, and treated fully their properties, uses and methods of detection.

To give the lectures a more practical bearing, it was deemed advisable to treat all the minerals taken up as ores of the more important metals and other economic products.

The general physical characters of minerals, such as form, hardness, color, streak, cleavage and fracture, were first considered, and the use of these characteristics in determining minerals carefully explained.

This was followed by a systematic treatment of the minerals of economic value, including those which occur in association with economic minerals and are classed as gangue minerals. These gangue minerals though of small commercial value in themselves were taken up in detail, for a knowledge of them was shown to be of great importance to the prospector on account of their association with the economic minerals occurring in the various ore deposits.

Special stress was laid on the value of field tests ; and the use of the magnetized knife, the lens, and other simple appliances was taught.

The lectures throughout were well illustrated, Canadian minerals, as far as possible, being used for the purpose.

Practical instruction with the blowpipe.

In the practical portion of the work the ordinary blowpipe tests for the common metals and other elements occurring in minerals were explained, and the students made to perform the operations for themselves. This was followed by the especial application of blowpipe tests for the identification of

the useful minerals themselves. The qualitative blowpipe assay for silver in galena was thoroughly taught, as the prospector who is acquainted with the process can decide in the field whether a galena is argentiferous or not, and thus save time and expense.

Occupation of men in the classes.

The men attending these classes were largely prospectors, miners and furnace or mill-men, mine owners and others more or less directly interested in the industry.

Number attending at Sudbury,

The number of students in regular attendance at Sudbury was eight, all of whom took both practical work and lectures.

at Copper Cliff,

At Copper Cliff the class numbered nineteen regularly enrolled students, taking both departments of the work.

and at Rat Portage.

The Rat Portage class numbered twenty-four, the majority of whom attended both lectures and practical work.

In addition to the numbers given above many others both at Sudbury and at Rat Portage attended the lectures from time to time.

Interest of students and the public in the work of instruction.

In closing we wish to express our high admiration of the intelligence and perseverance exhibited throughout the course by those attending. A live interest in the progress of the work was shown by the mining community at large, and many evidences of appreciation were evinced.

The opinion was expressed that these Summer Schools were a step in the right direction, and that much benefit to the mining industry would accrue from their continuation.

The want of practical instruction in matters of this kind had been long felt by the prospectors themselves, as the majority of them have neither the inclination nor the means to attend established schools of mining at distant places.

Although this, your first venture of the kind, has met with eminent success, we feel that that success would be still greater and the attendance largely increased if the classes were opened earlier in the spring.

Thanks for facilities afforded.

We cannot close without expressing our hearty thanks for the numerous courtesies extended to us by those with whom we were brought in contact. Especially are our thanks due to James Weidman, editor of the Record and secretary of the committee of organization formed at Rat Portage; also to the firm of Williams Bros. & Grey for the loan of samples of local minerals. To these and to others at Rat Portage we feel deeply indebted for facilities afforded us of becoming better acquainted with the region. At Sudbury we especially wish to thank James A. Orr, editor of the Sudbury Journal, the members of the school board and James McArthur, Esq., manager of the Canadian Copper Company's works.

Judging from the experience of the past summer and from the fact that many, in addition to this year's students, have already expressed the intention to take advantage of the opportunity were it again presented to them, the advisability of continuing these schools is undoubted.

Evidences of appreciation.

As an evidence of the appreciation shown for the work, we may state that at Sudbury and at Copper Cliff flattering resolutions of thanks were tendered us, and at Rat Portage we received a highly complimentary address

expressive of thanks and appreciation of the efforts of the School of Science, of the Ontario Government, and of ourselves to further the cause of mining education and of the mineral industry in the province of Ontario.

We have the honor to be,

Yours very respectfully,

W. E. BOUSTEAD,

W. A. PARKS.

School of Practical Science,
November 5, 1894.

MINING SCHOOLS IN NEW ZEALAND.

In New Zealand a steadily growing interest is maintained by the Government in providing technical instruction for the benefit of miners. Schools are maintained at Dunedin, Reefton and the Thames, where liberal courses are provided; and there are besides a number of smaller schools where an instructor attends occasionally, and where advanced students and gentlemen who take an interest in technical education give instruction and lectures. In his report on the goldfields of New Zealand for last year to the Minister of Mines, the Inspecting Engineer argues that in the pursuit of his avocation no ordinary degree of training is required by the miner. "To be able to successfully carry on mining operations in all its branches," he says, "a man must not only have a large practical experience in actual workings of mines, but he also must have a general knowledge of the chemistry of metals in order that he may analyze and ascertain the percentage of metals the ore contains; he must have a knowledge of mineralogy before he can identify the form and crystallization of the various mineral ores; a knowledge of geology, to be acquainted with faults, slides and heaves, to be able to determine the method of again discovering lodes which may be cut off and displaced by fault-movements, and to have a knowledge of the composition of the country rocks in which the minerals are found; . . . a knowledge of metallurgy, so as to be able to fully understand the best and most economic methods of extracting the various metals from the ores; and he also must have a fair knowledge of mathematics before he can understand the principle of and carry out underground surveys." From these points of view it will be seen that whoever adopts mining as an occupation requires a technical education as large and varied as that of almost any other profession.

Principal and minor schools for technical instruction.

Their utility.

At the Thames school in 1893 the average number of students was 91, of whom 40 were registered, and 51 attended the Saturday science lectures. The Director of the school reports that during the past four years 23 of the students have obtained employment in various capacities connected with mining, 10 as mine managers at salaries ranging from £200 to £350 a year, 6 as metallurgists in reduction works where the Cassel cyanide process is in use, from £125 to £200, and 7 as metallurgical assayers from £120 to £150. Since the beginning of 1890, 24 students have been prepared for the government examination of mine managers, of whom 21 have secured first-class certificates.

Thames school.

Reefton school.

The Reefton school shows a decreasing attendance, which is attributed to the repeated breaking up of the classes, occasioned by the Director's attending smaller schools in the outlying districts. "These short visits," he states, "which are of no practical value to the students, have seriously interfered with the Reefton school, which last year showed that good, sound and practical work was being done. The efficiency of this school," he adds, "can never be maintained unless the classes are carried on for at least nine months during the year without interruption. A month's instruction could then be given to two or three of the other schools, which would no doubt be of some value in keeping them together. In addition to the Reefton school the Director has given lectures and instruction to six other classes in various parts of the district.

Otago school.

The Otago School of Mines is attached to the University of Dunedin, and is doing good work. Nineteen students were in attendance during the session of 1893.

Minor schools.

The minor schools are nine in number, some of which are largely attended, but it does not appear that reports of the work done at them is made to the Government.

Cost of erection and maintenance.

The expenditure by the Government on Schools of Mines since their inauguration (in the nine financial years 1885-6 to 1893-4) exclusive of subsidies paid to the University of Otago, has been £12,895. For subsidies towards the erection and maintenance of schools of mines there has been paid £1,604; for chemicals, apparatus and mineralogical specimens supplied to schools, £942; and for salaries of teachers, travelling expenses, etc., £10,-348. For maintenance of the school attached to Otago University an additional sum of £4,250 has been paid; and the total expenditure of 1893-4 was £1,556.

Success of the schools.

"Those engaged in mining pursuits," the Mining Inspector says in his report to the Minister, "fully appreciate the advantages of a technical education at these institutions, and many avail themselves of the opportunity afforded of acquiring a theoretical knowledge of subjects connected with working of mines and treatment of ores, of which several of them have had many years' practical experience; and it is from such class of men that we may expect to find our future mine managers. The time has gone by when everything was done by the rule of thumb. Mines are now worked to much greater depths than in former years, and ores which a few years ago were considered valueless are now worked at a profit. On all the principal goldfields there are now men who can test and ascertain the value of ores met with, and this can be justily attributed to the establishment of the Schools of Mines."[1]

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[1] New Zealand Papers and Reports relating to Minerals and Mining, 1894, p. 21C3.

FIFTH REPORT OF

THE INSPECTOR OF MINES.

REPORT OF THE INSPECTOR.

To the Director of the Bureau of Mines:

Sir,—I have the honor to transmit to you my fifth Annual Report on the Inspection of Mines for the province of Ontario, being for the year 1894.

There has been no revival of work in the silver mines, as the market value of silver has been below the cost of its production in this province. Several of the large producing mines west of Fort Arthur are in a condition of comparative readiness for operation whenever the product can be placed upon the market at former prices. The same conditions exist in connection with the phosphate and mica properties in the eastern part of the province. Work has been entirely suspended on these mines throughout the year, though they stand in readiness to yield their full quota of returns when markets improve. The iron mines have also been idle.

The general outlook.

Suspension of operations in silver, iron and phosphate mines.

As will be shown by the report, there has been a marked improvement in prospecting for and in the development of gold properties, especially in the western portion of the province. The coming year apparently will be one of unusual activity in the production of the precious metal. Many new discoveries extending over a wide area have been made, and the extensive preparations for active operations both in mining and milling the ores will no doubt place this department of our mining industry on a much broader basis than it has ever attained before. This activity is the more encouraging from the fact that gold values never fluctuate to any appreciable extent, nor is the market liable to be overstocked. We may look for a permanency in gold mining which may be denied to almost every other class of minerals.

Activity in prospecting for gold.

The older copper and nickel mines in the region of Sudbury have been largely operated during the year, with the usual favorable returns, and as greater depth has been reached in some of them, especially in the Copper Cliff, with an excellent showing of ore, assurance is given that the large ore bodies exposed will not soon become exhausted.

Copper and nickel.

GOLD.

The Sultana island upon which Sultana mine is situated comprises 450 acres. For description see former report of the Director. On the 26th of July, the date of my visit, the main shaft of the mine, 7 by 14 feet, had reached a depth of 150 feet from the surface. At 66 feet from the surface No. 1 level was driven north 72 feet 4 in., stoping back 6,000 cubic feet; to the south it has been driven 62 feet 3 in., stoping 3,000 cubic feet. No. 2 level is 132 feet from surface, and was driven north 18 feet 6 in. and south 7 feet 6 in. Below No. 2 level the shaft was sunk 18 feet. At this date work was confined to drifting and sinking in the bottom level, sinking a

Sultana Mine.

Extent of workings on the property.

winze in the bottom of No. 1 level 50 feet north of the shaft, and stoping back of No. 1 level north. North of the main shaft 150 feet a perpendicular shaft was sunk away from the vein to the depth of 45 feet. South of the main shaft 132 feet a shaft was sunk on the vein to the depth of 40 feet, having a dip west 81 degrees. At the distance of 285 feet south of the main shaft and on vein No. 3 a shaft was sunk 45 feet. None of these outside shafts have been worked for the past three years. The work in the mine was under the supervision of Captain Z. J. S. Williams, and was done in a neat and substantial manner, with due regard to the safety of the workmen with the exception of walling off the ladderway from the part of the shaft used for hoisting ore, which I directed should be done. About 20 tons of ore was being lifted daily by the use of a small engine and conveyed to the mill, a distance of 250 feet.

Machinery and mill.

The machinery at the mine consists of a small double cylinder hoist 15 h.p., boiler 40 h.p.., air compressor 40 h.p., air receiver for Rand drills and two force pumps, one for feeding the boiler and one for pumping water out of the mine. For complete description of mill and equipment see pp. 18-19 of the Director's report of 1893. At the time of my inspection, the whole of the outfit was in good running order and doing excellent work. Suitable guards, however, were required to be placed around some parts of the machinery as a protection to the men, to which I called the attention of Captain Williams, who also had the supervision of the mill work. He stated that it would be immediately done. The mill has capacity for treating from 20 to 30 tons daily. About six cords of wood are consumed daily.

Report of progress by the mining captain.

In a recent communication from Capt. Williams he states: "The main shaft has been sunk to the total depth of 175 feet; the vein continues strong and well defined, now 4 feet wide, yielding a good grade of ore. The No. 1 level has not been continued. The No. 2 level has been extended north 40 feet and south 121 feet. A winze has been sunk in the bottom of No. 1 level north of the shaft to good pay ore. A raising stope has been put up from No. 2 level north to connect with the winze; this has opened out good ground. A good stope has also been opened in the back of No. 2 level south of the main shaft. Work in the main shaft has been suspended for some time, but it is now being sunk again. All the work ordered by you when at the Sultana has been done; the shaft has been divided and cased up between the ladder way and hoisting shaft and guards placed around machinery. Considerable stoping has been done on No. 3 vein off the shaft at the back of the mill. This vein is from 3 to 5 feet wide and yields good grade ore. There has been no additional machinery put in since you were here except one Rand drill, making three in constant use. The mill has been running regularly about 15 hours per day, and very satisfactory results obtained."

Employés.

A total force of 41 men were employed, 5 of whom are mill men, 24 on underground work and the remainder on work outside.

Buildings.

The buildings in connection with the mine are: Stamp mill, 130 by 75 feet; smith shop, 25 by 20; office, 30 by 20; assay office, 28 by 18; boarding house, 60 by 25; sleeping camp, 16 by 12; stable, 20 by 12; dock frontage,

135 feet. The magazine, 12 by 14 feet, is situated 500 feet distant from other buildings.

A small boat is used for transit to and from the mine to carry supplies, etc. in summer, and sleighs are used on the ice in winter.

Mr. John F. Caldwell of Winnipeg, the owner, spends most of his time at the mine, Captain Z. J. S. Williams has charge of the work in the mine and mill, and Mr. J. R. Bell is assayer.

Other properties.

Capt. Williams has kindly favored me with the description of the following properties, none of which were being worked at the date of my visit:

"The King mine, near Pine Portage mine, is owned by Mr. Kennedy. Here a tunnel is being run into the hill to intersect the vein at a depth of 76 feet from surface; this tunnel is now in 60 feet and they expect to intersect the vein in the next 10 feet.

"A property adjoining the Treasure mine near Rossland is being developed by Mr. Halstead of Chatham representing a Detroit syndicate. Here they have two shafts, one down 45 feet and the other 40 feet. This property looks well, and in all propability a ten-head stamp mill will be placed early in spring.

"Regina mine on White fish bay has been purchased by an English company. They have a shaft down 19 feet. Plans have been made for a ten-head stamp mill, which they intend erecting early this spring.

"Mr. J. F. Torrance of Montreal has been doing some developement work on the Morris locations, also near Rossland, for a Montreal syndicate. Several trial tests have been made on different veins with very satisfactory results."

Captain Williams also states that there are several shafts being opened on different locations in the Rainy Lake district, and it is reported that three stamp mills are now being erected, and that several more will go in early this spring.

Properties on the Seine river.

When at Port Arthur, July 30th, Colonel W. S. Ray, a banker, informed me that he had purchased a three-eighths interest in a property 34 miles east of Fort Francis, a quarter of a mile from Shoal lake and near the mouth of Seine river where it enters Rainy lake, known as A.L. 75, 40 acres. Mr. John Green of Fort William has an eighth interest, and Thomas Wiegand a miner, and the discoverer of the property, holds the remainder. Mr. Wiegand had recently taken up with the same parties A.L. 74, 41 acres and A.L. 76, 108 acres, all held by deed. The discovery of gold on A.L. 75 was made last spring and a shaft 6 by 7 feet was sunk to the depth of 12 feet, which was then filled with water. Prospecting was being done on other properties in the same region which had not been definitely located. Mr. Wiegand had left Port Arthur the Tuesday previous with a surveyor to locate five other properties. At this date other prospecting for gold had extended up Seine river as far as Shoal lake and beyond; Mr. Ray stated that they had done more work than any other party. Parties could go by tug direct from Fort Francis to the locations, and 12 miles beyond.

Colonel Ray states in a recent letter that the properties now owned by him on Seine river are embraced in eleven locations with an aggregate area

of 689 acres. Parcel AL75 has been purchased by Mr. J. C. Foley of Duluth for $12,000. A considerable amount of developement had been done on it previous to the transfer of ownership. Mr. Foley has let a contract to sink a shaft 100 feet and the results are looked for with much interest. Prospecting throughout the winter will be continued on several other of Mr. Ray's properities, and already a large number of veins have been exposed. On AL94 one shaft is sunk to the depth of 19 feet and another 7 feet. From these openings assays have been made showing $109, $110 and $120 per ton of gold, with from 80 cents to $3 in silver. At the date of his writing work was being done on a well mineralized vein of 7 feet width on A.L. 74. The great necessity at present is a road from the Canadian Pacific Railway to the Seine river. Mr. Ray suggests that Raleigh station would be a good starting point, and if a trail 8 feet wide were cut out it could be utilized for a winter road ; there is a fair canoe route which could be used in summer. At present people prefer going via Duluth instead of by Fort Frances. This is notonly diverting trade from our own province, but keeping explorers away.

Location AL75.

It will be of interest to note an official report made of the pioneer mine in this district by H. V. Winchell, M.E., of the Geological Survey of Minnesota, as late as November 15th, 1894. It was made to Col. Ray, as follows :

Winchell's report on the property.

"I take pleasure in handing you the following report on location AL75. Although I had no thought of making a report of this nature at the time I visited the property, and my report is for that reason incomplete in some respects, yet I found so much of interest there, and was so agreeably surprised with the showing already made, that I instituted quite a careful examination of the veins thus far uncovered, and of the geology of the immediate vicinity so far as it bears on the question of the probable richness and depth of the quartz veins.

"AL75 is a mining location taken under the laws of Ontario, and comprises about 40 acres. It is situated about one-fourth of a mile north of Shoal lake, which is merely an expansion of the Seine river, and about six miles east of Rainy lake.

"The estimated elevation of AL75 is from 40 feet to 60 feet above Shoal lake. There is an abundance of timber for mining purposes on the location and its vicinity. Water is plentiful close by, either in the lake or in small streams which flow into it.

"The region in general is embraced within the great area of Archean rocks which lies north and west of lake Superior, and is marked Laurentian and Huronian by the Canadian geologists.

"The rocks are of three principal varieties: 1, granite or gneiss ; 2, crystalline schist ; and 3, semi-crystalline or earthy green schists and slates. There are also in some localities dykes of trap rock and areas of eruptive granite and gabbro. The presence of the latter (eruptive rocks) has an important bearing upon the character of the quartz veins and will be discussed later.

"The strike of the rocks varies locally, but is prevailingly in an east-west or northeast or southwest direction.

"AL75 is largely if not entirely within one of these eruptive granite areas. This rock is not really granite, speaking from the mineralogist's standpoint, being composed largely of course grains of quartz enclosed in a grayish green hydrous-magnesian silicate like talc or serpentine. But it has the general aspect of granite, and is so marked on the geological map of the Canadian survey. On the north side of this granite or prolodyte as it may be called is an area of eruptive rock called gabbro by Dr. Lawson. It is a very old and much altered eruptive, but probably more recent than the granite. On the south side of A.L. 75 is a belt of eruptive greenstone, and still further south and southeast are found the sedimentary slates and schists lying unconformably on the granite.

"There appear to be two distinct classes of quartz veins in this region, and both classes are now being taken up and developed for mining purposes. The second class of veins cuts across the strike of the rocks, and hence has a general northerly trend. These veins are quite uniform in width, or at least do not change so suddenly as those of the first class, and have the appearance of true fissures. Some of them can be traced for a mile or more by outcroppings, and the walls are usually free or separated from the vein rock by a selvage and considerably slickensided. They occur in the granite and gabbro region and are occasionally quite heavily charged with galena, zinc-blende, pyrite, chalcopyrite, argentite (sulphide of silver) and visible gold. To this class of veins belong the veins on A.L. 75. Their dip is nearly vertical, or at a high angle to the east. Discovered by Thomas Wiegand, in September, 1893, considerable exploring was done during the summer of 1894, and at the time of my visit in October several different veins had been uncovered and traced for a considerable distance on the location, and test pits had been sunk on two of them.

"Pit No. 1, at the time I saw it, was 12 feet deep on the vein. Its width on the surface was about six inches, but at the bottom of the pit it had widened to about two feet. So far as opened up the vein was equally mineralized throughout its width. Some small stringers coming in from the walls contained visible gold. Just west of No. 1 about 75 feet is a vein three feet wide on which no prospecting has been done. The ore has a similar appearance to that in the other veins on the property. A sample taken of the ore thrown out of No. 1 pit, in which no gold could be seen, assayed $6.83 in gold and 15 cents in silver, a total of $6.98 per ton.

"Pit No. 2 on the west vein is about 150 feet from the west line of the location. This vein strikes north-south and dips east about 80 degrees. Its width, as shown in the 19-foot test pit, varied from one to three and a half feet. It is heavily charged with blende, pyrite and galena, and contains some chalcopyrite and black silver. Streaks and lumps of solid pyrite are found in it which show a good per cent. of gold on being crushed and washed in a pan. A sample taken to represent the average of the dump at this pit yielded $7.25 in gold and $1.55 in silver, or a total of $8.80. Another sample taken across the vein near the surface assayed $66.86 in gold and 30 cents in silver, a total of $67.16 per ton.

"Another vein was seen on this location ; it was about a foot wide and showed native gold on the surface when the moss was pulled off. No work has been done on this vein, and no sample was taken. All of these veins have good walls so far as they could be seen, and lead in a straight course across the location, cutting through the granite.

"It is a fact well known to economic geologists that the richest gold mines in the world are in the vicinity of eruptive rocks. It is now generally believed that the presence or absence of gold in quartz veins depends largely upon the presence or absence of heated solutions in circulation in these veins and the neighboring rocks at the time the veins were formed. These heated solutions are always active in volcanic regions, and in proximity to subterranean lava flows or masses. Where a new region is opened up therefore the first question to be settled is, are there any eruptive rocks there? If this question were asked regarding A.L. 75 an affirmative answer would be emphatically given, for, as we have seen, there is the granite suppósed to be eruptive, there is the grabbro north of the granite, and there is the greenstone south of it ; most decidedly a region of eruptive activity.

"The only conclusion that can be drawn from the foregoing statement of facts concerning the geology of this vicinity and the veins on this location, together with the result of the samples taken, is that it is a most promising prospect. The veins widen as depth is attained, and the ore is rich enough so far as the pits have been sunk to pay a handsome profit over the expense of mining and treating it."

On Bad Vermilion bay.

Other discoveries of much promise have been made, notably a property said to have been purchased recently by George H. Hillyer and Hugh Steel of the Russell Miller Mining Co., situated three-quarters of a mile east of the Bad Vermilion bay, on which a shaft has been sunk over 30 feet in depth with a well defined vein showing rich free gold.

The mining laws.

Concerning the mining laws the Duluth Herald says: "There is one thing that should be remedied immediately, for it militates greatly against the American side of the basin. That is the difficulty in obtaining title to mining claims. As soon as a man finds a claim he is met by a contest from some man who has made a timber and stone filing on his land, though he has never been within 150 miles of it. In Ontario the task of taking a mining claim is a very simple one, and the consequence will be that unless the matter is remedied the entire body of prospectors and developers will be driven to the Canadian side."

A large gold-bearing area to be prospected.

Mr. Peter McKellar of Fort William in a recent letter states that explorers have been busy during the past year between Fort William and Lake of the Woods, and many discoveries of free gold have been made, more especially in the vicinity of Savanne station, Eagle lake, Wabigoon lake, Manitou lake, Rainy lake, Shoal lake and Seine river. A test was made by Mr. McKellar last fall of 500 lb. of surface quartz taken from a late discovery made at Wabigoon lake by running it through the McKellar pulverizer. The button of gold from the amalgam saved weighs three grammes, value about \$2. This was the first trial on gold with the machine. The tailings

would still hold the greater portion of the gold, and were saved for further treatment. The test demonstrated the fact that the ore is an excellent milling ore, and if found in quantities the property is of much value. "It is the general impression of mining men here," adds Mr. McKellar, "that as the gold-bearing schist formation between Lake of the Woods and Thunder Bay district shows numerous veins and deposits of quartz, many of which have been proven to carry free gold, lively times will be witnessed the coming summer in prospecting and mining for gold throughout those localities."

A discovery near the Port Arthur, Duluth and Western Railway.

A gold property has been discovered one mile north of Lee Blain station on the Port Arthur, Duluth and Western Railway, and three miles east of the boundary line. The discovery was made in the fall of 1893 by Albert Quirt. Work in prospecting the property began in June last by sinking a shaft 6 by 6 feet to the depth of 22 feet, which was well protected by timbering. A well defined vein of $2\frac{1}{2}$ feet width has been followed, having a steep dip towards the north. The hanging wall is slate and the foot wall granite. Mr. Hille of Port Arthur states that the gangue consists of copper and iron pyrites, a little zinc-blende, lead, quartz and calcite. Assays which he made ran as high as $12 in gold. Mr. Broult, who gave to me the description of the location, has charge of the Customs office (American side) at the boundary line, the terminus of the railway.

Ophir Mine.

The Ophir gold mine is situated 16 miles north of Bruce Mines station on the Canadian Pacific Railway, Sault Ste. Marie branch, and on lot 12 in the 3rd concession of the township of Galbraith, district of Algoma. The inspection of this property was made the previous year by the Director of the Bureau, and a complete description of it was given in his annual report of last year. My first visit (March 9th, 1894) was on the occasion of an accident which occurred on the 5th March by the falling of a small fold of rock from the hanging wall, which killed three men and slightly injured two others, upon which I made a special report to the Commissioner of Crown Lands. Work at the mine was temporarily suspended at the time pending the investigation of the accident. The mine had been worked at first from the surface of the hill and three openings were made following the chimney of ore down to the depth of 25 or 30 feet with a dip of 45 degrees. Work was then extended lengthwise on the vein to a distance of 180 feet, slightly rising as the work advanced. A rock roof except at openings was left from 12 to 15 feet in thickness. The width between the foot and hanging walls is about 20 feet. The more recent workings began at the face of the hill some 20 feet below the upper workings; an adit was driven in on the vein, and as the work advanced the entire body of ore was stoped out between the walls to the upper drift. This drift was continued to the distance of 105 feet from the entrance. At 30 feet from the mouth barren rock was encountered, a portion of which was left standing for support to the hanging wall, the only pillar left for the entire distance. The width of the vein averaged 12 feet and about 35 tons were being removed daily, which carried from $5 to $6 per ton. A short distance from the mouth of the drift, at the base of the escarpment, a perpendicular shaft had been sunk to the depth of

Extent of the workings.

about 100 feet; also at the mouth of the drift an incline shaft had been sunk with a view to intersect the former one, but the connection was not made. Both were filled with water. Twenty-three men were usually employed at the mine and on outside work, and 9 in the mill, making in all a force of 32 men.

The mill.

The mill, which is about 40 tons capacity in 24 hours, was running and the machinery was in good order. About four cords of wood were consumed daily at the mill and at the pump house at lake Ickta from which the water is supplied for both mill and mine.

Unsafe condition of the mine.

The mine was not in a satisfactory condition, and I considered it necessary to give to the general manager the following written notice for its safe protection: "Before any further work is done on the floor of the drift in the mine I direct that substantial supports be placed in the mine, by placing upright stulls or timbers under the roofing and also against the hanging wall, with flagging overhead sufficient in number and strength to prevent any further cleavage of rock by action of frost or otherwise. Also, at the point indicated to-day for driving in a tunnel, leave standing a pillar of ore of not less than 15 or 20 feet in width before raising to the opening above, and as the tunnel or working is continued on the ore vein leave pillars sufficient in number and strength to support the hanging wall. Have the surface openings over the present underground workings properly fenced. Also put side railings on the tramway leading from the mine to the mill for such a distance out from the latter as may be necessary to protect from danger while working on it—perhaps as far out as where the tree fell across it."

The manager, Mr. Owen, discontinued his connection with the mine early in May, and Mr. Francis D. Taylor, M.E., of Brockville, who has spent many years in managing mining property, was appointed by the company to superintend the work. Soon after his appointment the following letter was received, dated 17th July:

Dear Sir,—Having been recently appointed superintendent of the Ophir mine by the Company, my attention has been called to certain instructions given by you to the said Company in a letter bearing date March 9th, 1894. In the first place, that in the event of carrying a drift easterly of the point where the accident occurred "a pillar was to be cut off and left of not less than twenty feet." Now as the vein matter has been tested in an easterly direction by drift for 120 feet more or less, the vein has not yielded in gold so satisfactorily as expected, and I desire to know if you will allow me to take out the ore by way of "stoping" between the level in question and the upper level or drift for twenty-five or thirty feet. I shall see and take every precaution to have the work well timbered and properly secured, so that no accident shall occur. You will please understand that the roof from the present entrance of this drift up to the point in question is carried safely and securely by strong stull timbers, and I am asking that you grant us the privilege of extension of this timbering from twenty to twenty-five feet further in same drift. I have given orders that the wishes expressed by you with regard to putting up a railing on the tramway leading from mill to mine be at once attended to. Also that the surface openings referred to be properly fenced off. Your acquiescence and a prompt reply will oblige yours most respectfully.

(Sgd.) Francis D. Taylor, M.E.

P. S.—Since you were here I have made complete plans, sections and cross-sections of the mine, and am keeping them up.

I complied with the superintendent's wishes, and at my next inspection found that the work had been done safely.

Early in August I again inspected the mine. The work was in a much improved condition under the supervision of Mr. Taylor. Twenty men were employed at the mine and in the mill. The mine was well secured by stull timbering and flagging over the workings. The extent of stopes was 33,760 cubic feet, and the drift was 166 feet beyond the stopes in barren ground. One shaft had been sunk to the vertical depth of 78 feet and the stope shaft was 66 feet in depth at a dip of 60 degrees south. No work was being done in either of them. No machinery was used in the mine, the drilling being done by hand. There is a tramway track from the floor of the level with a slight down grade over the trestle work to the upper part of the mill, over which the ore was trammed by hand from the mine to the mill, a distance of 411 feet. The stamps and feeders, a No. 5 Blake crusher, as well as the other machinery, are supplied with power by two boilers of 120 h.p. and an engine of 75 h.p. The eight Frue vanners with tables and cleaning-up pans were in good working order. The 4-inch discharge pump in the pump house at the lake was doing its work efficiently. The work both in mine and mill was being conducted with care, and in every part regard was paid to the safety of the workmen. The second inspection.

The outfit of buildings besides the mill is as follows: The manager's dwelling, cook house and dining room, mining bunks for mill and mining men, office, assay office, store, blacksmith shop, magazine, ice house, root house and stabling. All are conveniently arranged and neatly kept.

The Creighton property was operated to a limited extent in the early part of the year, when work was suspended with the exception of test borings, which gave favorable results. For a full description of the property see Director's report for 1893. In August, when at Sudbury, Mr. J. R. Gordon, the manager, stated to me that work would again be resumed at a not distant date. Recently the following interesting communication from Sudbury was made to the Globe of Toronto: "It is understood here that the Creighton Gold Mining Company are about to start active operations again on their property, some twenty miles west of here. After the mine closed down an expert mining engineer advised exploring with a diamond drill some 400 yards west of the shaft, and at a depth of about 200 feet a vein of quartz was struck indicating a total width of over 20 feet and showing several very rich specimens of free gold. It is understood that a meeting of the directors has been held at Ottawa and action taken to prove conclusively the extent of the ore body. Gold mining has been inactive in this locality recently, and it is thought that this discovery will arouse interest among owners of properties in the Vermilion river valley, as it is thought that the same vein which runs through the Creighton property extends throughout the whole valley." *Creighton Mine.* Exploratory work with a diamond drill.

The Bonanza gold mine is on lot 2, concession 4, township of McLennan, near lake Wahnapitae. A vertical shaft in this mine has been sunk to the depth of 50 feet and timbered for 30 feet through the broken formation. A drift has been run in on the vein 40 feet. A horse whim and pulsometer pump were used at the mine. I am indebted to Mr. Thomas Clemens, who did the developement work on the property, for the foregoing description. *Bonanza Mine.*

At that time (August 8th) work was suspended and the shaft filled with water. The property is owned by Berlin capitalists. The following extract is taken from the Toronto Globe of recent date: "The Bonanza Nickel Mining Company is engaged in developing a vein of gold on the shore of lake Wahnapitae, in the Nipissing district. The vein has a surface length of 1,600 feet, and a test assay gave returns of $100 a ton. A ton of the ore has been taken out and will be sent to the School of Mining at Kingston for thorough test."

Ledyard Mine.

The Ledyard mine is situated a short distance from the southeast corner of the east half of lot No. 19, in the first concession of Belmont township, county of Peterborough, 100 acres.

The property is owned by the Ledyard Gold Mine Company (Limited), with a capital stock of $1,000,000 in shares of $10 each; $150,000 reserved for working capital. President, T. D. Ledyard, Toronto; vice-president, T. H. Yeoman, Toronto; secretary-treasurer, T. H. Yeoman, Toronto; counsel, Charles Henderson, Toronto; mine address, Wariston P. O.

At the time of my inspection, July 12th, Mr. Fred. Straith Miller had the superintendence of the work. He stated that his experience in mining and engineering had stretched over a period of 40 years, 15 of which had been spent in Germany, 3 in Wales, and since 1872, when he came to Canada, he has had the direction of works in various parts of Ontario and Quebec. In 1893 this company engaged him as consulting engineer, and afterwards he had full charge of the work both in the mine and in the construction of the mill. Mr. John P. Williams, the captain of the mine, had been employed by the company for five months. He informed me that he had been engaged for 20 years mining in England, and since coming to Canada 8 years ago he had been constantly working in mines in different parts of the province. Mr. William Nichol was superintending the prospecting department and Mr. E. D. Ledyard was the company's secretary at the mine.

Developing the property.

A working shaft 8 by 11 feet had been sunk on an east and west vein to the depth of 60 feet at an angle of 80 degrees, which was well timbered down for 22 feet to the solid formation. Above the surface the timbering continued for 6 feet, showing the shaft from entrance down 28 feet to a landing, where the shaft below was closed with a door. From this point a drift 4½ by 10 feet had been run in east of the shaft 26 feet, following the vein of ore. Below the trap door the shaft had been sunk to a further depth of 20 feet at an angle of 68 degrees, when it became vertical and was carried down a still further depth of 18 feet. The vertical part of the shaft being filled with water, measurements of it were not taken, and of course I could not observe whether it was sunk in ore or not. In the working part of the shaft above the trap door the ladder way had not been walled off from the part through which the ore was lifted, and I gave instructions to have this completed before any further hoisting was done. The middle part of the shaft was properly timbered. The vein varies from 4 to 6 feet in width, with

hanging wall of chloritic schist and foot wall of talcose schist. The gold is disseminated through the vein of quartz. The ore is raised by a horse power derrick in buckets with timber guards, dumped into a car and conveyed over a tramway into the upper part of the mill, a distance of 100 feet eastward from the shaft. The trestle tramway is also continued in a westerly direction for the distance of about 600 feet from the shaft to a point known as the Burnt Knoll, on which the quartz vein crops out and where several surface openings had been made from which a considerable quantity of milling ore had been taken out. The elevated tram road required railing put on both sides, which I directed should be done. About 50 yards west of the Burnt Knoll another small mound occurs where gold bearing quartz was discovered at the surface, on which several test openings had been made with excellent showing of ore. The extensive area over which the ore-bearing rock crops out and the several test workings, together with the quantity of good grade ore now in sight in shaft No. 1, would apparently confirm the view that a large body of valuable ore exists and is easy of access on this property. It may be of interest to note several other discoveries to which Mr. Nichol, the prospector, called my attention. (1) North of the mill about 50 yards, where only a few shots had been put in, there was good showing of sulphurets and free gold. (2) About 100 yards still further north another discovery of sulphurets and free gold had been made, and the quality proved to be good by panning the former and crushing the quartz. (3) On the westerly part of the lot several veins have been uncovered, one showing the grade of ore as high as $22 per ton in the assay. (4) Recently, in addition to several others of less importance, Mr. Nichol discovered a large vein running north and south, on which considerable stripping had been done, showing excellent results both as to quantity and value of the ore carrying free gold.

The mill and its equipment.

The mill is a frame building 66 by 28 feet with a wing for boiler and engine of 41 by 16 feet. The height is 23 feet, with drop to the floor of 7 feet. Total elevation 30 feet. The machinery consists of a boiler 48 h.p., engine 35 h.p., a Northey pump to supply water tank of 4,000 gallons at the west end of the mill, the water being taken from a temporary reservoir the distance of 350 feet, and a Huntington gold mill. As the ore is conveyed into the upper part of the mill it is dumped over the grizzly. The coarse ore is then shovelled into a No. 2 Dodge crusher of capacity ranging from one to three tons per hour. Thence it passes into a rotary screen of half-inch mesh and the outfall goes into an elevator which returns it again to the crusher. The screened ore falls into a conical bin, and thence passes through the Tulloch automatic ore feeder, which supplies the $3\frac{1}{2}$ foot Huntington centrifugal roller quartz mill in which it is pulverized to pass through a 60-mesh screen, when it is received on three copper amalgamating plates each in succession, and from these the pulp passes into a trough with riffles and down into the button feed to the Golden Gate concentrator, where the concentrates are saved and the tailings pass out into the waste screen. The mill was started in my presence for the first time and the machinery worked smoothly, but its efficiency could not be determined until fairly tested by treating a quantity of ore. Mr. T. D. Ledyard, the president and managing director of the company, states in a recent letter:

"The Huntington mill which we have is unfortunately a second hand one of the smallest size, and has been continually breaking down and giving us a good deal of trouble, but we have now got it repaired and trust that it will work steadily. We are however getting a new 5-foot Huntington mill from Fraser & Chalmers, of Chicago, which we hope to have in operation shortly, and the capacity of the two mills should then be 20 to 25 tons of ore per day.'

Supply of ore and cost of mining and milling.

In submitting a report to the company on the supply of ore and cost of mining and milling the same, Mr. F. Straith Miller, M. E., says: "From the points already developed there will be no difficulty in keeping the mill supplied even if the capacity is increased three-fold, and as there are several other good veins on other parts of the property the future of these mines in regard to ore supplies can be looked upon as assured. I consider that there is enough ore in sight to keep the present mill going for several years, and it is only a question of men and money and power to open up and develop these and other rich veins which exist on the property, and thus increase the output to any desired extent. The cost of mining the ore, picking and tramming to mill, will not exceed two dollars, and probably when the open cut on the knoll is more advanced this will be much reduced. The cost of milling 15 tons per day I estimate at about 80 cents per ton, and if the mill capacity is increased to 50 tons per day both the milling and mining should be done for less than $2.50 per ton." But experience makes one cautious in accepting roseate estimates of gold properties at par value. It will be time enough to speak sanguinely when a much larger amount of developement work has been done.

Employés.

At the date of my visit 14 men were employed and the large boarding house constructed for the Belmont iron mine on the adjoining lot, and about half a mile from the mine was being used for boarding and lodging the workmen and for the clerk's office. In addition to the blacksmith shop, a mine office and assay room 30 by 12 was in process of erection, and a summer shanty capable of holding 16 to 20 men and a mining captain's shanty have been built.

Idle properties.

A number of gold properties formerly worked in the region of the Lake of the Woods as well as the Belmont, Crescent, Pierce, and Richardson gold mines in the vicinity of Marmora, have remained idle throughout the year.

On July 13th I visited the Marmora mill, known as the Walker-Carter process for the treatment of arsenical and other refractory ores. For a full description see the Director's report of the previous year.

The Walker-Carter process.

Mr. George E. Keith of Toronto had rented the mill and recently formed a company known as The Marmora Reduction Company with a capital stock of $24,000, of which he retained $15,000. The mill had been idle for a length of time except the department to recover the arsenic, which had been running for a few weeks previous to this date. About 8 tons of pure arsenic were on hand, and the total output since the mill started was about 20 tons; the commercial value rated in Montreal from $65 to $70 per ton. The new com-

pany intend to run the mill part on custom work, drawing supplies from the neighboring mines. A contract had been made for the delivery of 1,500 tons of ore. Mr. Keith informed me that the mineral contained in the mispickel ores in the Hastings region averages about 25 per cent. arsenic. The mill it was claimed would save from 85 to 90 per cent. of the gold contained in the ores. The plan of operating the mill will offer excellent opportunities to prospectors or parties desirous of working their mines without large capital. Ores brought to the mine would be treated at fair rates and the products of the mines could be immediately utilized for further development.

SILVER.

Mr. Peter McKellar of Fort William writes that the silver mines in Thunder Bay district are still lying idle, but there is some prospect that the Lily of the Valley may be operated again in the coming spring. In this connection I have taken the liberty of inserting a paper prepared by him relating to the silver bearing district of Thunder Bay which was read at the recent meeting of the Ontario Mining Institute held at Kingston.

The silver bearing district of Thunder Bay.

" A few years ago the silver mines of Thunder Bay were in active operation and much mining development was in progress; now all are closed down. The depression in the value of silver, occurring about the same time that a number of the prominent mines had penetrated down into the silicious or poor-bearing stratum of the Animikie rocks, resulted in the complete closing down of all the mines. Of course in time some of them will be reopened; not all, as many mines were started without a showing to justify work, as is generally the case in all mining districts. Other new discoveries will undoubtedly be made here, as there are lots of unexplored areas under cover of drifts and alluvial deposits, etc.

The Animikie formation.

" It was known to geologists and mining men for many years that the veins were richer in silver within the argillaceous stratum than within the underlying silicious stratum; but few of the mining men had much knowledge of the thickness of either, and were often disappointed in their mining operations on this account. As this characteristic is becoming better understood, many of the misdirected efforts of the past may be in future avoided. At Thunder bay the Animikie group of rocks covers an area of more than a thousand square miles. It consists principally of slaty beds, argillaceous and silicious, lying nearly horizontal upon the upturned edges of the highly inclined Archæan strata, which in this locality undoubtedly are largely Huronian schists. The thickness of the Animikie formation along the run of the western belt of silver mines, or from Silver harbor to Gunflint lake, 80 to 90 miles, will probably average 600 to 1,000 feet; but out towards the coast line it will be much thicker. The silicious or lower stratum, the lower silicious division of Mr. Ingall, is at the base of the Animikie rocks, and is about 400 feet thick at the Duncan mine and nearly 700 at the Beaver mine. It is not likely to exceed the latter thickness much anywhere along the northern silver belt. The carbonaceous slaty stratum that overlies the silicious stratum shows a thickness of about 300 feet; but along the northern

silver belt it has been partly or wholly removed by erosion and denudation in places; and in others it is covered with a bed or sheet of trap which, again to the southward is overlaid with slaty beds higher in the formation. In the mines along this belt all the rich deposits of silver were found in the veins within this argillaceous stratum, which in the southward direction dips under higher beds of the formation.

"It remains to be proven whether or not the argillaceous beds of the higher horizon have the same favorable influence on the deposition of the silver within them as the lower stratum has. From the past showing it would appear not, as in the great central belt, some ten miles or more in width, which lies immediately to the southward of the northern silver belt no rich silver lodes have yet been found like the mines on the western silver belt. This apparent barrenness of the central belt may be accounted for in two ways. First, that the lower argillaceous stratum is the real silver bearing stratum of the formation, in which case the veins here would have to be mined down through the overlying beds to reach the silver bearing stratum. Secondly, that the western silver belt seems to lie along a line of weakness, where there are many fissure veins, while along the central belt the veins are comparatively few and may not penetrate to the metalliferous reservoir to which I will refer further on. I consider the search for the causes that produced these silver-bearing veins a matter of much importance; that is, to try and find out if the silver in the veins is due to lateral segregation, or if it ascended in the fissures from a deep source, to be deposited subject to the laws of attraction or to the influence of the adjacent rocks. If the infilling is by lateral segregation it seems to me clear that in the Animikie group the veins need only be worked down to the lower silicious division, for the underlying Archæan strata are exposed in extensive areas here and there throughout the Algoma district. They show to be auriferous in many places; yet they do not show to be argentiferous in this respect anywhere, I believe, excepting in the vicinity of the great lake Superior trough, as at the Gopher and Star mines, Whitefish river, north of Whitefish lake, at the 3A mine north of Silver harbor, at the Cyrette location east of Nipigon bay; at the locations at the mouth of the Steel river, and at the Little Pic silver mines, west of the Little Pic river. These are all in the Archæan strata and carry silver ore similar to that of the Animikie veins; and in the case of the 3A and Gopher mines, rich ores. If the infilling is from below, we may look for these veins to prove valuable for mining to great depths, as the 3A mine and Gopher, etc., prove that some of the Archæan strata at least have the influence to cause the precipitation of silver in fissures within them when present in solution, as well as the argillaceous slates of the Animikie have. The greater showing of silver in the Animikie veins than in the Archean may be on account of the Animikie area occupying the more favorable position in relation to the metalliferous reservoir below.

Source of the silver ore.

"There is no doubt the Thunder Bay silver veins are true fissures, as shown by the faulting of the walls. The Silver Mountain vein shows a fault of 60 to 70 feet; the Beaver vein, 15 feet; the Rabbit Mountain much greater; the Duncan mine vein 120 feet etc.; so that the fissures must penetrate to a

great depth. It seems certain that the copper and silver of the native copper mines of lake Superior were ejected from great depths with the fluid rocks of the Keweenawan group, and also that the fissures of the silver veins here resulted from the subsidence in cooling of these great eruptions, and subsequent to the flow of the fluid rocks. The previous fissures formed were filled with fluid rock and show now as trap dykes in great numbers, especially along and near the coast. It is highly probable that those fissures cut down to the great reservoir from which the eruptive rocks of the Keweenawan were ejected; heated vapors, steam and aqueous solutions would ascend in the fissures, and carry metals and minerals along; and continue the ascension and precipitation of the solution subject to the influences of the adjacent rocks until the fissures were filled as we find them. In the event of the argillaceous beds having a greater influence in depositing the silver than the interstratified silicious beds that the Animikie have, the veins within the former should show richer in silver than within the latter, as we find them. So also with the underlying Archæan strata, it is quite probable that the veins will be rich in silver within some of them and poor within others in a similar way. The middle of the lake Superior trough, the portion opposite Thunder bay, appears to have been the most metalliferous part of the great reservoir, for all the great copper mines are here on the one side and the silver mines on the other. Although the rock formations continue westward for 200 miles or more, the rich mines do not show excepting around the middle portion of the trough.

Faulting of the vien walls.

"There are two series of fissure veins here; those of the most numerous nearly east and west, about parallel with the great trough; those across, prominently developed along the outer coast line, and rarely penetrating far inland. The position of the latter series near the middle of the trough, might be expected to prove richer than the other series of veins. The Silver Islet vein is one of them, and is certainly the richest one known thus far. If it can be proven satisfactorily that these veins carry the silver in the underlying Archæan strata, this locality is likely to prove a valuable deep mining district. I consider it quite probable that it will do so in view of the natural conditions that bear on the matter, some of which I have in this paper endeavored to show."

Two series of fissure viens.

COPPER AND NICKEL.

Mr. Joseph Cozens of Sault Ste. Marie states that no additional developement work has been done on his mine on Michipicoten island since the report of the Royal Commission on the Mineral Resources of Ontario, 1890. The excellent outfit of buildings and plant at the mine are kept in good condition. In July last the water was removed and the mine was thoroughly explored by Senator Pascoe of Michigan, the gentleman who opened the celebrated Calumet and Hecla mines, and who has had charge of the Republic mine for the past 21 years. He made a favorable report upon the property, and Mr. Cozens anticipates that a syndicate will be formed at an early date and that the mine will be operated again.

Michipicoten island.

A conglomerate lode has been discovered in the stratified formation on the west end of the island, about a mile and a quarter west of the old workings. It is 20 feet in width and has been opened to the distance of 4,000 feet, with cross cuttings showing good ore. Two bands of excellent sandstone of about one foot in thickness each have been uncovered.

Exploration work at Point Mamainse.

Early in August, when at Sault Ste. Marie, I met Captain T. H. Trethewey, who has had charge of the work in the mining locations of the Copper Creek Mining Co. at Point Mamainse. Mr. T. advised that as the work then being done on the property was so very limited and of such a diversified character, but little could be gained by going over it at this date. About a dozen men were employed in groups of two and three, doing exclusively exploring work. Work had been suspended on the main shaft, which was then nearly filled with water. Its total depth was 308 feet, at an angle of 57 degrees east, and it was properly cribbed from surface down to the solid formation. Besides the drifts at 80 feet from the surface previously reported, another at the bottom of the shaft had been extended southward for some distance, in which chambering had been done for a reservoir. The other workings consist of cuts and shafts, over 100 in number, varying from a few feet to 48 in depth and extending in different directions over an area of about 4,000 acres. The shafts were properly covered when left, and in those where valuable ore was found in considerable quantities work would be resumed in the future; the barren ones were entirely abandoned. Most of these openings at this date were filled with debris or water. In a recent letter Captain Trethewey writes : "All operations at Mamainse were closed a short time after you were here (Aug. 2), a few feet of drifting at the bottom of the shaft (308 ft.) were done, making a total distance from the shaft of 100 feet. This is about all the change made." For a complete description of the property see the Director's exhaustive report for 1893.

Copper Cliff Mine.

On March 12th work in the Copper Cliff mine was confined to sinking a new shaft at an incline of $77\frac{1}{2}$ degrees, starting in the old shaft at the third level, the object being to reach the deposit of ore at the deepest part of the mine without having to run in drifts at so great a distance as that required from the old shaft, which has an angle of about 40 degrees. The continuance of the large deposit of ore at this depth offered a sufficient reason to make the outlay for the new shaft. It was also intended to sink the new shaft below the seventh level to a sufficient depth to open up the body of ore on the eighth level. Much time and expense would be saved in tramming the ore the shorter distance to the hoist. At this date the new shaft had reached the fifth level, and the greater part of the force of 38 men then employed were engaged in timbering this part of it. The work was being neatly and skilfully done under the direction of Captain Davis, and with due regard to the safety of the workmen. On the completion of the new shaft the old one would be abandoned for working purposes from the third level down. At the depth of the seventh level the ore deposit was 95 by 150 feet.

Sinking a new shaft from the third level.

Roasting the ore.

One smelter was running at this date and treating about 100 tons of ore daily with a force of 60 hands ; 20,000 tons of roasted ore were on hand, and

the contractor stated that the following week 4,000 additional tons would be calcined, and about 1,600 the week after. Mr. Trist had 55 men on the roast yard at this date. The work was being carefully managed.

My second inspection of the mine was made August 10th, when a few days were occupied in examining the work both in the mine and the outside departments. The management was the same as at my former visit. The total force of 51 men were employed at the mine at this date, 31 of whom were on underground work. There was also an additional force engaged at the smelters and roast yard and other outside work. About 150 tons of ore were being mined daily. Second inspection.

As I had been supplied with an Inspector's Book and wished to make the entries of the work done in the mine as complete as possible, considerable time was spent in taking measurements and securing an accurate description of the whole work up to date. Captain Davis gave to me his undivided assistance in doing this work. We obtained valuable aid by the use of some of the tracings of the work made by recent surveys of the mine. The old shaft, 8 by 16 feet, had been sunk to the depth of over 500 feet at an incline of 40 degrees. Shaft No. 2, or new shaft, 8 by 17 feet, with incline of $77\frac{1}{2}$ degrees, starts from the third level in the old shaft at 150 feet from the surface. The distance in this shaft on its incline from No. 3 to No. 4 level is 50 feet; from No. 4 to No. 5 level, $51\frac{1}{2}$ feet; from No. 5 to No. 6 level, 56 feet; and from No. 6 to No. 7 level, 54 feet. The shaft was also continued below the seventh level to the depth of 35 feet at this measurement, and sinking was still going on. Total depth of shaft at incline at this date, $396\frac{1}{2}$ feet. This shaft was substantially timbered and the ladder way with short rests properly divided from the hoisting part, and all was in excellent working order down to the seventh level. On examining the part of the shaft below this level I found the formation firm, and the walls were carefully trimmed as the work proceeded. Solid pentice timbering gave safe protection from the work above. The Inspector's Book. Measurements of the new and old shafts.

The old shaft is on an incline of 40 degrees. From the surface to level No. 1 is 58 feet. At this level a drift has been extended west 110 feet, another southeast 200 feet. There is a stope east of the shaft 40 by 50 feet and a cross-cut 40 feet. From level No. 1 to No. 2 is 40 feet. A drift northwesterly from the shaft has been run in 100 feet, with a cross-cut of 36 feet out near the end. The stope on the east side of the shaft is 15 by 30 feet. The depth from No. 2 to No. 3 level is 83 feet. A drift has been run in west 50 feet, which thence turns north 75 feet and a cross-cut of 25 feet at the point of the angle. A drift was also extended east of the shaft 50 feet and turns north 55 feet, thence east 75 feet, with a stope at the back end 30 by 40 feet. From level No. 3 to No. 4 is 82 feet. The drift northeast of the shaft extends 150 feet with a stope at the back end 30 by 50 feet. A cross-cut at 75 feet from the shaft extends northwest 75 feet. From No. 4 to No. 5 level the depth is 65 feet; a drift starting east of the shaft and circling northward was driven in 50 feet, thence angling northwest 100 feet. At 40 feet from the extremity is a cross-cut of 40 feet. From the fifth to the sixth level the depth is 87 feet. In this level a drift starting northeast

from the shaft circles to the north and is driven in 300 feet. From the sixth to the seventh level the depth is 86 feet. A drift east of the shaft and northward has been run in 335 feet, extending 40 feet north of the new shaft with a stope of 40 by 90 feet. The distance from the new shaft to intersect the body of ore is 40 feet, while in the old shaft the distance is nearly 300 feet. A stope from No. 2 level extending downwards to the floor of the fifth level had been made and pillars were left as supports. This stope was being continued to the sixth level by removing the floor of the fifth, leaving the pillars remaining. This extensive opening is smaller at the top and widens to the extent of 100 by 110 feet at the sixth level. A winze had been opened between the sixth and seventh levels and on the floor of the seventh level a large quantity of ore had been shot down preparatory to hoisting. In addition to the day and night shifts in sinking the shaft, a considerable force of workmen were employed in the fifth and sixth levels in removing ore.

Precautionary measures.

As these were the principal places of working at the date of my inspection, I spent considerable time in company with the captain and underground foreman in carefully looking over the work as then progressing, which presented a satisfactory appearance. Constant changes however would occur as the work proceeded, but the captain stated that each gang of men after blasting scaled the walls in the vicinity of their own work, besides which a few good men were sent into the mine every Sunday at midnight, when the mine would be free from smoke, and were occupied until seven o'clock Monday morning in making a general survey of the different places of working, and all rock presenting any dangerous appearance was removed. Suitable appliances, such as ladders, ropes, etc., were kept on hand for this purpose.

Machinery.

The machinery in use at the mine consists of a hoisting engine, air compressor, 80 h.p. boiler, double drum hoist, three pumps, and rock breaker, with boiler and engine. Five drills were being worked and two skips were in use.

The smelters.

The smelters were running at their ordinary capacity, and employed the usual force of workmen. A new cupola had just arrived and would soon be put in place, while one of the old ones would undergo repairs. The matte was not being bessemerized at this date. At No. 1 smelter there were two boilers, one engine, one Baker blower, one water-jacketed furnace and water-jacketed wells. At No. 2 smelter are one engine, one Baker blower, one water-jacketed furnace, and water-jacketed wells. The boiler at No. 1 is used for both smelters. The bessemer plant is made up of one cupola, one blowing engine, two boilers, three rotary converters, three hydraulic cylinders for revolving converters, one rock breaker pug mill, one hydraulic elevator, one hydraulic pump and one supply pump.

The company own a good diamond drill outfit, which is occasionally used for exploiting by boring.

The roast yard.

A large supply of ore, roasted or in process of roasting, was on the roast yard and Mr. R. W. Trist, the contractor for this department of the work, informed me that he usually employed from 70 to 80 men roasting and delivering the ore at the smelters. The work was being carefully and properly

managed. The engineer accompanied me over the trestle railway track, which I found in excellent condition.

The following note was entered in the Inspector's Book at this date: "I found the mine in a much improved condition and being carefully worked under the direction of Captain H. Davis. It is well ventilated and apparently in a safe condition. The machinery at both mine and smelters, as well as the bessemer plant, was in good order and safely protected from danger to the workmen."

Third inspection.

On September 22nd I again visited the mine on the occasion of an accident which occurred on the 15th by the fall of rock from the roof of the seventh level, proving fatal to two of the workmen and slightly injuring another. I spent considerable time in the mine at that date, but more particularly in examining the cause of the accident, a special report of which was made to the Commissioner of Crown Lands. The killing of the unfortunate men I regarded as entirely accidental, and the coroner's jury at the inquest took the same view of the occurrence and attributed blame to no party in connection with the mine. For the time being all work was suspended in the mine, but would be resumed shortly. The captain fully concurred in my direction that the entire roof of the level should be scaled before further work was done in it. Operations had been continued in the same parts of the mine as when I visited it the month previous, and its condition, except the advanced stages of the work, had not much altered. The day and night shifts had been constantly engaged in sinking the shaft, and at this date its depth was about 75 feet below the seventh level.

Investigating a fatal accident.

Progress of operations.

I received in December notice of work closing, except for exploring and fitting up the mine for winter. Captain Davis in a recent letter informs me that the stope between the sixth and seventh levels had been broken through, and that the ore in this part of the working would be removed by spring. The new shaft was sunk to the eighth level, 93 feet below the seventh. He writes: "We have it well timbered that far down and skips running in good shape. We have our drift in at the eighth level towards the ore body about 30 feet. The pentice is in below the eighth level, and we are now sinking towards the ninth level and have reached a depth of 44 feet from the eighth level, or a total from the seventh level of 137 feet. We are sinking a winze in the seventh level on the ore body to intersect the eighth level to secure proper ventilation and to aid in stoping." The winze at the time of his writing was down 50 feet. The week previous a new steel cable had been put in the west part of the shaft, as the old one had become too short.

Granulated slag.

Manager McArthur informs me that no additions of any kind have been made to the smelters or roast beds. The granulated slag dumps are assuming large proportions. "The slag granulating system works like a charm," he writes. No. 1 furnace has been granulating its slags day and night, summer and winter, for the last eighteen months without a hitch of any kind, running out about 50,000 tons of granulated slag. No. 2 slag granulator and elevator started up on the first of June last and gave equally good satisfaction, having since then run out about 18,000 tons of granulates. Practically the hardest, most fatiguing, and somewhat dangerous work of pot-hauling is now a thing

of the past. There are now two elevated tramcar tracks stretching from the top of each elevator shaft for the distance of about 200 feet to the outer edge of the old slag dumps and these roadways are entirely covered in, roof and sides, for the whole distance as protection to the workmen. All the works are kept in a safe condition.

Two fatal accidents occurred in the mine during the year in addition to the one mentioned above. On November 24th Axel Johnson fell down a shaft and was killed. On December 10th a rock fell on the plank upon which William Martin, who was assisting in timbering the main shaft, was standing, and he was thrown down the shaft and received injuries from which he died two days afterwards. The accidents were of such a nature that I was not requested to make special reports upon them.

Official returns furnished by the head office show that this Company's mines produced from their opening up to December 1st about 400,000 tons of smelting ore, and 41,600 tons of matte, which is equivalent to 7,638 tons of refined nickel; but the whole of the ore has not been smelted.

Evans Mine.

First inspection.

At the Evans mine on March 12th the work was just being opened up, as operations had ceased in the fall previous and the mine had been standing idle throughout the winter. Work had been resumed only on the Wednesday previous to my visit. A total of 64 men were employed, 45 underground, some of whom were busy trimming walls and fitting up the mine in proper shape for work. Stoping to a limited extent had commenced in the second, third, fourth and fifth levels; also in the open pit; and about 125 tons of ore had been hoisted daily for the two or three days previous. A much larger quantity per diem would be taken out when the work became properly regulated. Seven drills were in use or being placed, and an additional one in the open pit. During the respite of regular mining work four test bores had been made in the deepest workings of the mine with the diamond drill of the respective depths of 35, 45, 55 and 115 feet. The holes had been plugged to prevent the inflow of water. The rock crusher had been started first the Thursday previous, and the ore was being prepared and hauled by cars to the roast yard at Copper Cliff, where the ore is roasted from the three large mines operated by the company. I found the mine in a fairly good condition, with the exception of a few places which were being put in order as expeditiously as possible. The machinery was in good running order.

Second inspection.

Measurements.

At the date of my second inspection (August 8th) I made a general survey of the work done up to that time, and made also the proper entry of the same in the Inspector's Book. The work consists of one open pit near the rock house, 96 by 106 feet and 100 feet in depth, and a vertical shaft 8 by 12 feet to the depth of 263 feet, with 10 feet of water at the bottom. No. 1 level at 50 feet from surface was driven in north, and has been worked partly out in an open pit. It still extends north of the open pit in unstoped ground 75 feet. On the south side of the shaft a stope has been made 25 by 25 feet with a raise of 30 feet. No. 2 level at 100 feet from the surface has been extended west 75 feet. No. 3 level is 48 feet below No. 2, and south and near by the shaft a stope has been made 34 by 97 feet with a raise of 30 feet.

In level No. 4, 57 feet below No. 3, north of the shaft an extensive stope 76 by 87 feet with a raise of 30 feet has been worked out, with substantial pillars left to support the roof. The fifth level is down 48 feet below the fourth and a stope south of the shaft 51 by 60 feet with a raise of 30 feet in the centre has been made ; also there is north of shaft a stope 19 by 50 feet, with a raise of 25 feet.

From No. 2 level an underhand stope has extended down to No. 4 level. It is of small size at the top of the opening, but measures at No. 3 level 40 by 40 feet and at the floor of No. 4 level 42 by 49 feet.

Working force.

The work was under the direction of Captain Davis, with Mr. Thomas Hambly as foreman, who has been in the service of this company five years and at the Evans mine three years. The usual force of workmen was employed, and about 190 tons of ore raised daily.

Machinery.

The machinery used at the mine, which was in excellent condition, consists of a hoisting engine, compressor, four boilers, rock house engine, rock crusher and screens, three steam pumps in the mine, one cage, seven Rand drills and all other appliances required to keep up repairs, etc.

Condition of the mine.

The condition of the mine as well as the outside department of the work bore evident traces of careful supervision, and but little was required by way of direction for the safety of the workmen.

Stobie Mine.

In compliance with section 62 of the Mines Act I received notice from the manager of the Canadian Copper Company, under date of 21st July, that they were again operating the Stobie mine. On August 9th I visited the mine and made a thorough examination of the works.

Measurements

The open pit, 130 feet westerly from the rock house, 47 by 90 feet, had been sunk to the depth of 70 feet. There were 12 or 15 feet of standing water at the deepest part. There is a bench westward from the open pit and near the tunnel of 30 by 47 and from floor to surface 30 feet. A small stope has been made under the hanging wall of the west side of the pit extending back 30 feet. I directed that before further advance be made on this stope a substantial pillar should be left to support the roof. No work at this date was being done in this opening. A drift still advances westerly 120 feet, with a stope at the entrance 26 by 36 feet with a raise of 25 feet. At the west end of the drift the stope was raised to the surface, leaving an open pit work of 41 by 48 feet with a depth of 33 feet from the surface. There is a skip track at an incline of 30 degrees running from the top of the rock house down to the place of working in the open pit, a distance of 150 feet, and about 175 tons of ore are trammed out daily. A total of 56 men were employed at the mine, with 33 of the force on underground work under the direction of Mr. Samuel Bryant as foreman. Captain Davis, who has the supervision of the company's three mines, Copper Cliff, Evans and Stobie, accompanied me to the mine and assisted in taking the measurements of the work described.

Machinery.

The machinery consists of two boilers, one hoist engine, compressor, engine for rock breaker, screens and tables. Two skips are operated. There was a small compressor and boiler standing idle. The piston rod of the com-

pressor required to be cased for safety, which I gave notice to have done, as well as suitable guards to be placed around the fly-wheels of the same. Otherwise the mine and machinery were in good condition.

Rock house.

On a careful examination of the spacious rock house I found that it was heavily laden with ore, and it showed slight indications of spreading, to which I at once called the attention of the captain of the mine and also of the master mechanic. The captain gave immediate instructions to have a much less quantity of ore kept on the crushing floor at a time in the future. The master mechanic, Mr. Greeg, informed me soon after that the building had been substantially stayed and that the casing and guards had been placed at the compressor as directed. Work at this mine closed down early in the fall.

Worthington Mine.

At the date of my first inspection of this mine (March 10) 70 laborers were employed, and about 75 tons of high grade ore were mined daily and shipped to the roast yard at Blezard. The mine was in a safe condition and the machinery used was in excellent running order and doing the work efficiently.

Second inspection.

The workings at the second inspection (August 6th) consisted of shaft No. 2 now in disuse except for ventilation, which was the first shaft sunk. It is 100 feet deep and is connected with the shaft No. 1 by a drift going west at a depth from surface of 70 feet. Shaft No. 1, at a distance of 100 feet from shaft No. 2, is 180 feet deep. Fifty feet down the first level is driven west 80 feet. Sixty feet below this level No. 2 is driven 56 feet west and 20 feet east to the second shaft for ventilation. Level No. 3 is 65 feet lower, or 175 feet from surface, and is driven 20 feet west; thence it turns and goes south 24 feet. Between levels No. 1 and 2 west a stope is being worked at this date about 20 by 35 feet. Stoping also has been done between shafts No. 1 and No. 2, but not to a large extent. The plant is composed of two steam boilers, air compressor, hoist, crusher and conveyor, two steam pumps and drills. The air receiver on the compressor required to have a covering to insure safety, and the fly wheels on the same to be protected by railing, which I directed should be done; also that the explosives should be taken into the mine in a covered cannister. Otherwise the mine at this date was in a safe condition and the machinery in good order.

Measurements.

Mining plant.

Seventy-two men were employed at the mine. Captain McBride had charge of the mine work, and Mr. Ian Cameron is still the company's general manager. A large quantity of excellent grade ore was being taken from the mine. Two to four cars were loaded daily, to be taken to the roast yard at Blezard mine, where ten additional men were employed. The week previous 23 cars of ore of 18 tons each, being over 400 tons, were shipped from the mine. About 16,000 tons of ore were on hand. The smelter at the Blezard mine had been standing idle since November last, but would be started up again as soon as the coke came down to near its former prices. At this time it was ranging $1.40 per ton dearer than formerly. About 20 tons were used daily when the smelter was operated to its full capacity, equalling a loss at present prices of some $28 per day should the smelter be run. At the date of my last visit to the locality the smelter had been started but a few days.

Output of the mine.

The following plant is used at the smelter: Locomotive, two boilers, engine, blower, water pump, water-jacketed smelter, with water-jacketed well.

The manager in a late communication says: "We stopped mining at the Worthington on the 14th of September, since when we have been smelting continually at Blezard."

Blezard Mine. The Blezard mine, also owned by the Dominion Mineral Company, has been lying idle throughout the year.

Murray Mine. I found the Murray mine at my first inspection (March 13) in a safe condition and the work progressing in the usual manner. No special changes had been made since my previous visit, except in the advanced stages of the work, a description of which is given below. About the usual force of laborers were employed, and a very considerable quantity of ore was being taken out daily and conveyed to the roast heaps.

The smelter. Mr. Thomas G. Saunders had been acting for four months as foreman at the smelter, Mr. H. W. Edwards having decided to accept the offer of a more lucrative situation. Mr. Saunders had been previously foreman of the Orford Company's works at Constable Hook, N. J., for refining nickel and other ores, notably copper, and held his connection with that company for 15 years. A single smelter was running continuously and treating 100 tons of ore daily. All the matte is re-treated previous to the weekly shipments. A force of 80 laborers was employed, including mechanics, those employed about the roast yard and at general work. About 5,000 tons of ore, roasted or in process of roasting, were on hand. A large supply of coal and coke had been provided, and 7,000 cords of wood were in the yard. The smelter was in good order and running successfully.

Second inspection. A second inspection of the mine was made August 8th, when a total of 140 laborers were employed at the mine and smelter. About 60 were at the mine, 45 of whom were on underground work, and about 80 tons of ore were mined daily. I secured as complete a description as possible of the entire work done in the mine up to date for entry of notes in the inspector's book.

Measurements. There are three shafts. The one known as No. 6 is vertical, being the main shaft for pumping and hoisting. Shaft No. 4 is 112 feet northeast from No. 6, and is sunk to the depth of 56 feet and used at present for ventilation. There is also a stoped shaft northeast from No. 4, 305 feet. This was a test shaft and the open pit is 26 feet deep. The first level in No. 6 shaft is 56 feet from the surface. Stoping has been carried on northeast and west-southwest, extending along the strike northeast 200 feet. At intervals of 30 to 45 feet stopes 20 feet high have been opened out towards the hanging boundary. From foot wall to hanging wall the average width is 60 feet. Pillars 20 to 30 feet square supporting the roof also separate one stope from another. On the southwest side the same system exists, but the extension along the strike is 160 feet. No. 2 level in shaft No. 6 is 100 feet from the surface. Drifting northeast has been extended 160 feet. Two stopes 30 feet high have been opened out towards the hanging wall, leaving a width of 30 feet. A middle pillar 30 by 40 feet supports the hanging wall and floor of level No. 1.

On the southwest side drifting has proceeded 94 feet. At 25 feet from the shaft a stope 30 feet high, 30 by 30 feet, has been made. This side of the mine is at present idle.

Extension of work since my inspection in March may be summed thus: from the second level at a distance of 80 degrees northwest of No. 6 shaft a sub-shaft has been sunk to the third level and the northwest drift extended 10 feet. At the end of the northwest drift, second level, an advance of 20 feet. A rise is being put up to communicate with the first level. This rise is up 30 feet. Stoping at this date was confined to the ore body between the first and second levels.

Plant.

For drilling purposes five air drills are in use, driven by an Ingersoll air compressor at the surface. Hoisting is done by an efficient vertical steam engine near the rock house, where a Blake stone crusher is worked by a separate and adjacent engine for that purpose. A horizontal steam hoist has been recently fixed at the mouth of the sub-shaft for hoisting purposes. A cage and cars are used.

State of the mine.

The system of mining is especially adapted to the health and safety of the workmen. The roof of stopes is everywhere well arched. Captain Richards stated that frequent inspections were made for detection of any loose scales. Ventilation is well secured by connection of No. 4 shaft with No. 6. No. 4 is an up-cast. The collar of this shaft has lately been heightened several feet above the surface, so as to produce an improved and well-defined circulatory current of air.

The smelter.

The smelter on August 7th was running from 80 to 100 tons daily with about 40 laborers, part of whom were on the ore roast yard. The furnace is water-jacketed and the well lined with fire brick. The last well stood for five months, but usually the lining fails in about half this time. The material used for other lining purposes are fire clay and skimpings obtained from the old Bruce mines.

Bessemerizing the matte.

When smelted the molten matte of from 10 to 12 per cent. metal contents is drawn off into the converters and subjected to a cold blast which is forced into the mass under a pressure of 8 lb. to the square inch, and when the charge is sufficiently oxidized it is drawn out into pots and allowed to stand five or six hours for cooling. The refined matte, now raised to 70 per cent., settles by gravitation to the bottom and is easily separated from the slag at the surface. When broken off, if any portion of the slag is too valuable for the waste dump it is broken up and mixed with roasted ore, and passes again through the smelter. A car of from 18 to 20 tons of matte is shipped weekly. The boiler, engine and air compressor I found in good working condition.

About 7,000 tons of ore were on hand, roasted and being roasted. Twelve cords of wood were consumed daily, with a large stock on hand.

Trilabelle Mine.

The Trilabelle mine is on lots 10 and 11 in concession 3 of Trill, about 40 miles west of Sudbury. It is owned by a Duluth syndicate of which Mr. H. W. Wheeler is president. Mr. George W. Mann has had the management of the work, and he has employed from 20 to 30 laborers for a part of the season. Besides sinking a shaft 60 feet in depth and doing some other deve-

lopement work, a good road of easy gradient has been made out to the mine from the Travers mine owned by the Drury Nickel Company, thereby forming a connection out to Worthington, a distance of about 13 miles. The ore body I am informed has been tested to the width of several hundred feet, and is of high grade and easy of access. When I was visiting the other mines in the locality work in this mine was suspended and the shaft was filled with water. The working force was engaged in constructing the road and doing other outside work preparatory to more extensive operations. Developement work.

The property owned by the Drury Nickel Company, known as the Travers mine, has been lying idle during the year. The Beatrice mine has also remained unworked. Properties idle.

IRON.

On August 3rd I drove out ten miles west of Ottertail to the old property generally known as the Stobie iron mine, which is in the township of Coffin, near Desert lake, and which was then being tested by drilling to prove the extent of the deposit of iron. It is nine miles north of Stobie station and about 35 miles east of Sault Ste. Marie. A railway charter was obtained last year by the Portlock & Desert Lake Railway Company to construct a road from Portlock harbor, near Stobie station, to the mine, a distance of ten miles. The property comprises Y8, 157 acres; A2, 320 acres; A1, 357 acres. Total, 834 acres. Mr. James Stobie retains a tenth interest in Y8, and the remainder of this section, together with the other two, are owned by the Cleveland Rolling Mills Company and Mr. George Rankin. Mr. Stobie operated this property several years ago by sinking test shafts, when a limited quantity of the ore was shipped to Detroit and the test by smelting proved the ore to be of good grade and free from impurities. Should the ore body be found by the present test borings in sufficient quantity, it is then intended to erect a smelter at the harbor for its treatment. Prospecting with a diamond drill in Coffin township.

A suitable outfit for doing the work had been brought on the ground some time previous to my visit, but a delay in obtaining the diamond drill had permitted only a few days' work to be done up to that date. One bore had been put down on Y8 to the depth of 56 feet without favorable results, and the plant was then being removed about 1½ miles east near to the place where the deepest shaft had been formerly sunk. The bore at this point will be sunk at an angle of 45 degrees and to a depth of from 300 to 500 feet.

A boiler of 15 h. p. was being used, and also a Sullivan drill with capacity to bore 500 feet, the diameter of bore being 15-16 of an inch. The outfit had been purchased from the United Bessemer Mining Co. of Michigan. A Cameron pump with 400 feet of piping was on hand.

The work was under the direction of Mr. Alexander McKee, an old miner, and Mr. George Rankin, who was at the works. Mr. Rankin has engaged Mr. Frank Newett, recently from the Ashland mine, Michigan, to do the drilling. A comfortable boarding house with stabling and other necessary buildings had been provided, and five laborers were employed.

Mr. T. D. Ledyard of Toronto writes of recent date as follows: "The Belmont Bessemer Ore Co., 29 Broadway, New York, who have leased my Belmont Bessemer Ore Company.

property known as the Belmont iron mine on the west half of lot 19 in the first concession of Belmont, are making arrangements with the Cobourg, Northumberland and Pacific Railway to complete the railway from the iron mine to the Canadian Pacific Railway, and when completed the C. P. R. will operate it as part of the Cobourg Railway, which they have leased. The Belmont Bessemer Ore Company expect to supply the Hamilton Furnace Company with a considerable amount of their magnetic ore."

BARYTES.

Testing the McKellar island mineral.

Peter McKellar of Fort William in a recent letter favors me with the following items of information respecting the barytes lode, on McKellar island, in lake Superior : "The mine has been purchased by Messrs. Barnes & Upton of Duluth, and a payment made. They have been testing the ore, and several hundred tons have been used with good results. Manufacturing works have been erected in Duluth, and it is expected the barytes mine will be extensively worked next summer."

GYPSUM.

Paris Mine.

My first visit to the Paris gypsum mine, which is situated on the north side of the Grand river about $1\frac{1}{2}$ miles east of the town of Paris, was made on May 10th. Mining had been carried on constantly throughout the winter and spring by a force of three workmen, who took out from 4 to 5 tons daily by contract. This mine was in a very unsafe condition at the date of my last inspection, and I gave directions to have some parts of the drift refitted by placing new stulls in the dangerous places with good flagging overhead. This however was not done, and just a day prior to my visit a part of the drift crushed in. Fortunately this occurred in the night time, after the men had left the work, and thus they escaped being entombed. It was now decided to run in a new drift to the gypsum layer, commencing at a point east of the old one, and to construct it of sufficient size to admit of the use of a horse or mule to haul out the plaster. Timbers at this time were being brought on the ground for supports to the drift, and day and night shifts would be worked until the ore was reached at the supposed distance of about 125 feet from the entrance. When completed mining would be continued with about the same number of men. The class of gypsum is similar to that formerly reported.

Plaster and alabastine mill.

About 500 tons of plaster had been received at the Paris mill during the present year up to date on a contract for 1,000 tons from the Adamant Company's mine, near Cayuga. The manager, Mr. Wheeler, informed me that another 1,000 tons besides the present contract would be required from this source to meet the demand for the year. Besides a large quantity ground for fertilizing purposes, a very considerable amount of calcined plaster was prepared, the demand for which had greatly increased. The alabastine manufactured at the company's mill, the only place of its production in Canada, has met with a ready sale. Also the potato bug finish, put up in barrels of

350 lb. each, has been distributed largely throughout the country and has become generally used as an effective agent in the destruction of the Colorado beetle, while its fertilizing qualities are valuable to the crop. The mill, which had been running both day and night for some time past with an increase of workmen, was in good running order.

Second inspection.

On my second inspection of the mine (December 21st) I found the new drift, 450 feet east of the old one, substantially constructed. It had been driven in 171 feet due south, when it intersected the layer of gray gypsum from four to five feet in thickness. It was continued in the same course along the bed about 100 feet, opening up a fine face of mineral on the west side of the drift. Three men were working in the mine, removing from three to four tons daily by contract at $1 per ton, and were placing it in the ore shed at the mouth of the drift. Thence it is hauled a distance of 1½ miles to the mill in the town, where it is ground as land plaster.

The mining had been carried on for three months previous to my visit. In the former part of the year about 750 tons had been taken out through the old drift, when the work ceased by reason of the falling in of the roof. I found the mine at this visit in a greatly improved and safe condition.

Eight hands were working in the mill. The plaster, of which there was a large stock on hand, was being ground for land use. A new buhr-stone was being placed for grinding gypsum for alabastine, of which the sales during the present year had been larger than in any former one. About 2,200 barrels of potato bug finish had also been disposed of.

Mr. T. W. Wheeler had still the management. Mr. R. E. Hare had charge of the milling, and Mr. John Ray was employed as millwright.

Martindale Mine.

The Martindale mine has been worked by two men for about five months during the year, and about 200 tons of gypsum taken out. The work is done by contract. The day I was at the mine it was idle, and but little change in its condition was apparent since my former report.

Excelsior Mine.

Excelsior mine, which is 2½ miles east of Cayuga, had been worked up to August with four men, and about 1,000 tons of gypsum had been taken out; 500 tons were still remaining at the mine, and since that time no work had been done at it. Since the former report describing the work a drift has been run in at the foot of the incline, west 50 yards. In the drifts there are tram tracks laid near the face of the layer of gypsum, and as this is removed for several feet back tracks are relaid nearer the gypsum, and the open space is walled up with waste rock to support the flat roof. The mine (December 19th) required to be carefully refitted before work was resumed to make it safe. Mr. T. A. Nelles, who has charge, promised that this should be done, and timbers were then being brought on the ground for the work. Since then he has reported to me that the refitting has been completed, and asking that I would again come down and look over it.

Teasdale Mine.

After about 75 tons of ore had been taken out of the Teasdale mine all work in it was abandoned on account of the inflow of water, and from this cause it may not be worked again. There was a large body of gypsum exposed.

Garland Mine. On December 20th Mr. Henry Wilkinson had charge of the Garland mine, and two men with him were taking out about five tons of ore daily at a cost of $1.35 per ton. As formerly, the gypsum is carted to Caledonia and ground for land use. At the bottom of the incline, which has been run in westerly from the surface 100 yards, the gypsum bed is reached, and a drift in a north-easterly direction has been run in 50 yards to the present place of working. The drifts vary in their ccurses in all the gypsum mines as the work progresses, the old ones being filled as new ones are opened. An area of from two to three acres has been worked over in this mine, and labor was confined at the date of my visit to working out a large pillar of ore which had been left standing as a support, and which would require about one month yet to accomplish.

Several years ago a shaft was sunk 65 yards northeast from the mouth of the present working drift, where a layer of gypsum was reached of from five to six feet in thickness, and it was intended as soon as the pillar was removed in the old workings to open an incline drift to reach this layer of gypsum, the extent of which has not yet been fully explored. After holidays it was expected that a larger number of workmen would be employed.

The condition of the mine was somewhat better than at my former inspection. The old workings however will soon be abandoned, as the ore is nearly exhausted.

Gypsum discovered at Caledonia.

It may be of interest to state that while visiting the boring for natural gas in the town of Caledonia, which was being driven down on the north side of the Grand river for Mr. Robert E. Walker of that place, a discovery of gypsum was made. On this well the boring was down 65 feet at the time of my visit, December 20th, although 20 feet additional was sunk that day. At a depth of 40 feet from the surface the 8-inch bore passed through a layer of white gypsum four feet in thickness, and at the depth of 59 feet a thin layer was pierced of very pure white gypsum. The bore was in common limestone, from 20 to 25 feet from surface.

At a depth of 380 feet it was expected to strike the Clinton formation, which is composed of a layer of limestone about 20 feet in thickness, and a layer of slate or shale 10 feet in thickness. Then follows the red Medina sandstone of 40 feet in thickness, below which is a layer of slate of 50 feet in thickness and the white Medina sandstone of 15 to 20 feet in thickness. Sometimes gas is obtained in this formation. Beneath the Medina is the Hudson River shale, which averages about 700 feet in thickness. These formations, I was informed by Mr. Carmody, who was employed in sinking here, apply to all the places where bores have been put down. At a depth of 100 feet the Niagara limestone was reached, which is here about 240 feet in thickness, and in this formation in places there was a liberal flow of strong brine. The best flow of gas in the wells sunk in Caledonia is from the Clinton limestone. Three wells had been sunk : one 500 feet, with 90-lb. pressure ; one 550 feet, with 240-lb. pressure ; and one 350 feet, with 90-lb pressure. The third was not completed at the date of my visit. The first two wells

Borings for natural gas.

were sunk by contract at $1,500 and $1,200 respectively. The demand for natural gas here was greatly beyond the supply of the wells. One furnace and about a dozen stoves, with a few burners, were being supplied.

I have the honor to be, Sir,

Your obedient servant,

A. SLAGHT,

Inspector.

WATERFORD, March 13, 1895.

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